THE
POPULAR SCIENCE
MONTHLY.

APRIL, 1913

THE INFLUENCE OF FORESTS UPON CLIMATE

By Professor ROBERT DeC. WARD
HARVARD UNIVERSITY

Introduction: Popular Belief in Forest Influences, and its Possible Origin

FAR and wide, the world over, we find a popular belief in an influence of forests upon climate, especially upon rainfall. This is not difficult to explain. Take our own experience, for example. On a summer day we leave the hot, sunny road and walk along a narrow forest path. The trees give shade; the glare and heat of the road are replaced by the soft, dark carpet of leaves and moss; the air seems cool and damp. It is all a great relief, and the impression is inevitable that a forest climate is different from that of the open. Again, on a spring day, when the snow has disappeared from the fields, but when a chilly, wintry wind is blowing, we leave the open meadow and cross a patch of woodland. There is snow still lying deep under the trees; there is welcome protection from the biting wind; it seems pleasantly warm. Has not, we naturally say, the forest a climate all of its own? Once more. We observe, the world over, that where there are extended forests there is heavy rainfall, and we see deserts and treeless areas where the rainfall is light. We infer that the forests have something to do with producing the heavier rainfall, and some of us may even go a step farther and think that the great treeless areas were once forested, and that deforestation has made them dry. Or, to give one more case, we may have noticed the increasing tree-growth with increasing elevation on our mountains, and may have concluded that the denser forest is the cause of the heavier precipitation which is generally observable as we ascend our mountain slopes.

Thus it may come about, naturally enough, that people believe in forest influences upon climate. Yet, if we ourselves happen to have

based our own belief on any such evidence as the foregoing, we ought to remember that our own sensation of heat, or cold, or dampness, by no means necessarily, or even usually, corresponds with the actual meteorological facts. Further, the great rainy and dry belts of the earth's surface are controlled by a world-wide distribution of temperature, pressure and winds, that is, by the general circulation of the atmosphere, and by conditions of the higher strata far and away beyond the reach of any local effects such as those of a forest. Universally, in response to natural controls, a scanty rainfall is hostile to tree-growth, and forests are favored by heavy rainfall, which gives good conditions of soil-moisture and is generally accompanied by higher relative humidity, more cloudiness and less extreme temperatures than prevail over treeless regions. In the case of mountains, again, it should be clearly in our minds that, as a rule, and up to a certain limit, an increase of altitude involves an increase of precipitation, quite apart from the presence or absence of any forest. We must be careful not to put the cart before the horse. The forests, in other words, are the result of the rainfall, and not *vice versa.*

Importance of the Subject: its Complexity

That this subject has an important relation to our national conservation policy no one will deny. Unfortunately, the discussion of it has become more or less a matter of semi-political controversy. Much has been written without adequate study of the question. Heated arguments, *pro* and *con,* have been advanced in debates and in print. Remarkably divergent views have been, and are to-day, held upon the question. It has been claimed that forests have no climatic influences whatever. On the other hand, some have believed that deforestation in North America has affected the climate of Europe. A recent writer maintains that the principal cause of the "intellectual and industrial stagnation" of the Spanish peasants is to be found in the effects of deforestation in making the climate drier, so that the people are "worked to death to support life." The literature is extended and bewildering. It runs back at least five hundred years. A bibliography published in 1872 contains nearly two hundred titles, and began with Fernando Columbus, who attributed the heavy rainfall of Jamaica to its heavy forests, and a (supposed) decrease of rainfall on the Azores and Canaries to deforestation. It has been said that this whole discussion first came up in really acute form at the time of the French Revolution, when private timberlands were largely destroyed.

The subject is thus greatly complicated by the nature of the discussion. It is, furthermore, by its very nature a complicated problem. On the one hand, climate itself is the complex resultant of many different controls. Among these are the latitude; the elevation above sea-level; the varying influences of land and water; the proximity of ocean currents; the prevailing winds and storms. In this list of controls, but at

the end, the last and the least important of all, modifying slightly, perhaps, the total effect of all the other controls, comes the surface-covering of the earth. This may be snow, or grass, or sand, or lava. Here belongs the forest, a special kind of surface covering.

On the other hand, the forests. What do we mean by forests? Do we mean the vast, dense tropical forests of the Amazon, or a grove of trees on a New England farm? Have we in mind evergreen or deciduous trees, or both? Are the forest trees tall or scrubby? Is their height uniform or varying? Is there undergrowth or is the forest clean? Are we considering the forested slope of a steep and lofty mountain or the trees in a valley bottom; a tropical or an extra-tropical forest; a region of heavy or one of moderate rainfall; of much or of little cloud? Clearly, a complex problem is here before us. No wonder that so much diversity of opinion exists with regard to it. Few of those who discuss the question are at all aware of its extent or complexity. They see only one or two small aspects of it, and upon a very insufficient, and often inaccurate, knowledge they base broad and misleading generalizations.

In a matter of such general interest it is most important to proceed carefully, and to see clearly just what we do, and what we do not *know*. That is the purpose of the present paper: to set forth, as the writer sees it, the status of the "forest and climate" discussion in the light of the available *facts*. It may be added, parenthetically, that it is only comparatively recently that a scientific study of the subject has been possible.

The Historical Method of Treatment: its Unreliable Results

The favorite method of attacking the problem of forest influences has been the historical method. Probably the large majority of those who believe in such influences are affected, consciously or unconsciously, by the use of historical arguments. A certain region, we hear, was once forested. There are now few or no traces. "People" say that the climate there has "changed." Hence, the disappearance of the forests must have produced the change of climate. This is not an unfair illustration of the historical argument. Sometimes, of course, simple hearsay, and general impressions, are replaced by actual records of the change in area covered by trees, and by rainfall observations (extending over a relatively short period), or by rough accounts of the depth of water in rivers and streams. But, at best, this method of treatment is very unreliable. All the elements in the discussion are uncertain: the early forest conditions; the supposed "change" of climate; the accuracy of any available meteorological observations. Granted that a "change" of climate has actually taken place, was the so-called "change" the cause, or the effect, of the change in forest cover? And may not the "change" have been the result of the well-known oscillations of the climatic pendulum, which bring periods of wetter and then

of drier years, and which are, therefore, more, or less, favorable to forest growth?

The historical argument may be illustrated by the following:

The valley of Aragua, in Venezuela, is shut in on all sides, and the rivers which water it, having no outlet to the sea, unite and form Lake Tacarigua. This lake during the last thirty years of the past century showed a gradual drying up, for which no cause could be assigned. In the beginning of the present century the valley became the theater of deadly feuds during the war of independence, which lasted twenty-two years. During that time land remained uncultivated, and forests, which grow so rapidly in the tropics, soon covered a great part of the country. In 1822 Boussingault observed that the waters of the lake had risen, and that much land formerly cultivated was at that time under water. The drying up of the river Scamander in the Troad, and the contracting of the Euphrates in its channel, may be referred to as illustrations of the same effect of the cutting down of forests, and of diminished vegetation. (Buchan's "Introductory Text-book of Meteorology," 1871, p. 50.)

Clearly, we have nothing beyond the merest hearsay evidence in all this, and absolutely no facts upon which to base a scientific conclusion.

Again, in regard to Greece:

In the course of centuries, the forests have in large measure been destroyed . . . and with the passing of the trees the rainfall has decreased, so that during the summer months, when hardly a shower comes to moisten the parched earth, the country is for the most part extremely arid. (Clarence H. Young, *Bulletin American Geographical Society*, Vol. 32, 1900, p. 151.)

Those with even an elementary knowledge of the climatic zones will recall that Greece, like northern California and northern Africa, lies in the subtropical belt, whose dry, or even wholly rainless summers, depend upon the great controls of temperature and pressure and winds and storm-tracks, far and away beyond the reach of any such insignificant local agencies as a few trees.

Or again:

The rainfall (of Teheran) was formerly very much less, say up to 10 or 11 years ago; it then did not, I think, exceed five inches per annum, but it is now about ten. The great increase is no doubt due to the many gardens which have sprung up within the last 10 years in and outside the city, and perhaps also to the formation, 10 years ago, of a lake 50 miles south of Teheran. The lake has a length of 22 miles, and is from 3 to 6 miles broad. (A. Hontum Schwindler, *Symons's Monthly Meteorological Magazine*, Vol. 28, 1893, p. 145.)

This is a good example of the weakness of the historical argument, even when apparently based upon actual observations.

We might cite further the rather hackneyed examples from Trinidad, where the cause of a general but rather slight decrease in the mean annual rainfall for ten-year periods between 1862 and 1891 (from between 66.50 and 67 inches at the beginning of the period to slightly over 65 inches at the end) has been "said to be the disappearance of the forests"; from Kimberley, where the cutting down of trees to supply timbers for the mines is supposed to have had "most injurious effects on the climate," increasing the number of dust-storms, among other effects; from Ismailia, where tree-growth since the opening of the

Suez Canal is said to have brought an increased rainfall; from the Peninsula of Sinai, from Syria and from Algeria, in all of which deforestation is said to have changed luxuriant and fertile districts into deserts. One other example, quoted by a recent writer, may, perhaps, be referred to:

> In 1551 the Marquis of Northampton went from Orleans to Nantes (on the river Loire), with his suite, in "five large, many-cabined boats," whereas navigation is now impossible above Saumur, the distance of which from Nantes is less than half that of Orleans. This change is ascribed to the deforestation carried on extensively in the surrounding country in the seventeenth century, and the consequent diminution in the volume of water in the Loire due to diminished rainfall.

There is no need to multiply these examples. They show, clearly enough, why the historical method is unsafe, and why it has given but meager results.

An Essential Consideration: Why Should Forests Influence Climate?

It is a curious fact that so few of those who are firmly convinced that climate is affected by forests, ever seem to ask themselves: "Why *should* forests influence climate?" We seem to accept it as a fact without asking ourselves why it should be so. If we stop a moment to consider the reasons which come to mind, we shall probably sooner or later enumerate them about as follows:

(*a*) Because forests must retard and obstruct air movement, favoring calms, and causing the air to ascend slightly over the trees. Both of these effects may be favorable, in a small way, to rainfall. The barrier effect, by reducing the velocity of high winds, ought to moderate the extremes of winter cold.

(*b*) By means of their shade, trees ought to check the warming of the ground, and of the air, especially in summer.

(*c*) Because of the retention of moisture in the forest litter, and of the decreased evaporation which may be expected to result from the lessened air movement under the trees, it seems not unreasonable to expect that forest air will be somewhat damper than that outside. This, under proper conditions, may also favor rainfall.

(*d*) The diffusion of the water vapor transpired by and evaporated from the leaves may perhaps increase the opportunity for rainfall.

(*e*) We may expect the tree cover to diminish nocturnal radiation from the ground underneath, and thus to maintain a slightly higher temperature within the forest than outside of it at night.

(*f*) Also, there may be some effect from the increased radiating surface due to the presence of the leaves or needles. This must be chiefly effective at night.

(*g*) The heating of the leaves must be less than that of bare ground, because of the evaporation of much water from the leaves, and because

of the slow heating of the water in the leaves. To a certain slight extent, then, a forest cover ought to behave as does a water surface; it ought to warm a little less rapidly and therefore it ought to cool less rapidly.

(*h*) The process of growth of the trees, and the chemical changes which are going on during their life, must require an expenditure of energy whose effect might possibly be observable in a difference of temperature between the forest and the open. The rise and return of the sap may also be expected to be accompanied by certain slight temperature effects resulting from the transfer of root temperatures upwards and of crown temperatures downwards.

In these, and perhaps in other ways, we may seek for the causes of forest influences upon climate. But, whatever may be the theoretical reasons for believing in such influences, we are here concerned only with the facts as they are at present known. One further word of caution is necessary. It is one thing for a forest to have a climate of its own within its own limits, under or above the trees. It is quite another thing for a forest to affect the climate of the surrounding country, or of distant regions. The latter effect is naturally the one in which the real interest centers. But it is also the one which is by far the most difficult to study. It is clear that nothing more than reasonably local modifications of climate ought to be expected. The special climate of the forest itself—so far as it may appear to have one—can only affect the surroundings by modifying the air currents which pass through or over it, by producing an ascending movement of the forest air to take part in the prevailing wind movement, or by causing, as may happen under especially favorable conditions, local air currents of its own. Most, if not all, of the above-mentioned theoretical effects of forests upon climate have been overestimated.

Forests as Wind-breaks

The most obvious effect of forests is that of the barrier, or wind-break. First, there is far less wind movement within the forest than there is outside. Second, friction on the tree-tops reduces the velocity of the wind blowing over the forest. Third, to leeward of the forest there is a belt of relative calm which is roughly ten to fifteen times as wide as the forest is high, as has been determined by measurements in Iowa and in the Rhone Valley. More recently, in Roumania, Murat has shown that within 165 feet to leeward the decrease in velocity may be from four to eight miles an hour, and that the effect of the forest in decreasing velocity extends as far as 1,500 feet to leeward. Some years ago, comparative observations in the harbor, city and suburbs of New York and Boston showed a remarkable reduction in wind velocities with increasing distance inland, the velocities in the city being a little over three fifths, and those in the suburbs about one third, of those in the harbor.

Clearly, then, wind-breaks such as those which have been recommended for, and are found in, much of our western treeless area furnish considerable protection, over a narrow strip to leeward of the trees, against the sweep of strong hot or cold winds. Such a reduction in wind-velocity may have beneficial effects in reducing somewhat the extremes of heat or cold, and in diminishing evaporation from soil and from plants, and perhaps also in checking the blowing away of the soil. On the other hand, frost is more likely to occur where there is less air movement. Deforestation, on a large scale, especially on extended level areas, will therefore favor a freer sweep of the wind, which may be hostile to the growth of crops. Over any extended treeless area, exposed to high winds and with a severe climate, the best protection will be found in the planting of narrow belts of trees, alternating with agricultural strips. It should be noted, however, that this very wind-break, by decreasing wind velocity, keeps the air of the forest interior from affecting the atmospheric conditions round about. In other words, the forest diminishes its own climatic influence.

Influence of Forests upon Temperature

There is comparatively little popular interest in any possible influence of forests upon temperature, attention being almost altogether focused on the rainfall factor. Upon their soil temperatures, forests have a slight cooling effect (up to about 5°) attributable to the shade and to the greater moisture of the forest floor; the extremes are retarded and reduced; frost penetrates less deeply. Between evergreen and deciduous forests there is this difference, that in the former sunshine has freer access to the ground, and warms and dries it better than in the latter. In general, a forest climate bears a faint resemblance to a marine climate in having a slightly smaller range of temperature than the open, the extremes being most moderated in summer. In central Europe the mean annual minima are about 2° higher in the forest, and the mean annual maxima are about 4° lower. Individual summer maxima may be 6° to 8° lower in the forest, and individual winter minima 3° higher (Prussia). Conditions in the United States are probably not very different, although our greater extremes of heat and cold here would perhaps lead us to expect a slightly greater forest effect in moderating these extremes. The sum-total effect is, therefore, a slightly cooling one, chiefly because the forest is a little cooler than the open in summer, and about the same, or very slightly warmer, in winter. But these temperature differences in the average of the year are very small, and even in individual cases are certainly usually inappreciable without the use of thermometers. The considerable difference in our feelings of heat and cold ("sensible temperature") within and outside of a forest is probably chiefly due to the combination of the other factors, such as wind movement, moisture, exposure to sunshine, etc. Indeed, a good many of the reported differences between field and forest are probably

too large, owing to unfavorable exposure of the thermometers. It is, however, significant that the presence of relatively cool air over forests has been indicated by the fact that balloons, in passing over forested sections, often have a distinct tendency to descend. This cooling effect above the forest is pretty clearly of more importance than any temperature effect within the forest, but we have as yet very little reliable information on this phase of our problem.

It is to be expected that equatorial forests should have more marked effects in lowering the temperature than temperate forests. The high maxima reached over the deserts of the lower latitudes, largely as a result of the excessive heating of the sandy surface, do not occur where the dense equatorial forests shade the ground; increase the radiating surface by means of their leaves; supply much water vapor through transpiration and evaporation, and possibly also, by favoring fog and cloud formation, cut off sunshine. Woeikof has done good service in calling attention to this important function of tropical forests. We must not, however, suppose that scattering forest patches in our temperate latitudes can have any notable effects upon temperature. As Supan has well stated the case, in speaking of the very "moderate" effect of forests on temperature:

> No one will care to maintain that the system of isotherms would be radically altered if Europe and Asia were one great forest from ocean to ocean.

Influence of Forests upon Humidity and Evaporation

Within European forests the relative humidity exceeds that over the neighboring glades or fields by a few per cent. (2–10 per cent.). This is an expectable condition, and no doubt in part due to the slightly lower average temperature in the forest. The local formation of dew might be favored on this account. It appears, further, that evergreen forests have more influence in increasing relative humidity than do deciduous forests. Evaporation from free water surfaces within forests is a little less than one half of that in the open, a fact which is to be explained chiefly by the decreased air movement, and, to a much less extent, by the slightly lower temperature and the slightly higher relative humidity. In addition to the action of forests in decreasing evaporation, there is the positive effect of supplying moisture to the air through the process of transpiration. The amount of moisture thus given off from the leaves of the forest has been estimated to vary from three times that from a horizontal water surface of the same extent to less than half that from the water. Evaporation is, of course, much the most active under sunshine. In Central Europe the annual amount of transpiration in forests consisting of well-grown beeches and oaks has been estimated to be about one quarter of the total precipitation.

It is apparent that, as rain-bearing winds progress inland from the ocean, their tendency to continue rainy will be favored if they pass over extended forest areas instead of over bare soil, or even over grass or

crop-covered surfaces. It is also a well-known fact that a certain portion of the rainfall of continental interiors is supplied from secondary sources *not* the ocean, such as lakes, rivers, swamps, and to some slight extent even from the forests themselves. But the forests must of course have received the water before they can give it up; they can not supply it by and through themselves. There seems to be no really very good reason for thinking that the rainfall conditions of the interior of North America would be very much changed if all the forests bordering on the coasts were replaced by crops or by grass. It is foolish for us to think that the forests are more important than the ocean in supplying water vapor for rainfall. Without the rainfall supplied by the vapor evaporated from the oceans the existing forests would never have grown at all. The amounts of moisture concerned in the great rain-producing processes of the atmosphere are so large that the local supply from forests can not conceivably play any considerable part. A recent German writer has stated his opinion that

> It is beyond any question that a forest can not increase the moisture-content of the atmosphere as a whole. On the contrary, it takes from the air a large amount of moisture which has been brought from the ocean by warm ascending currents. Indeed, under certain weather conditions extended forests even favor a decrease of cloudiness by producing a descending current of air, in contrast with the ascending current produced over an easily-warmed open field.

INFLUENCE OF FORESTS UPON RAINFALL: WHY DO WE EXPECT IT?

Thus we come to the phase of the discussion which is of much the greatest popular interest. Do forests increase rainfall? Does deforestation result in a decrease of rainfall? It is almost inevitable that the majority of persons should approach these questions with a fairly strong prejudice on the affirmative side. There is the general and universal impression in favor of such an influence, already referred to in the opening paragraph of this paper. In addition, the theoretical considerations above enumerated turn our thoughts in the same direction. By way of a review, then, let us ask, What are our reasons, at this stage of our discussion, for thinking that forests may influence rainfall? First, the barrier and frictional effect, which, by forcing horizontal air currents to rise, should tend to favor condensation, as cloud, and perhaps also as rainfall. The slackening of the air movement above an extended forest ought to increase the thickness of the stratum of moving air, thus giving it a slight, and local, ascending component. This same slackening effect should produce a tendency to light winds and calms, which are often favorable to showers and local thunderstorms, especially if the air is damp. Second, the damper and slightly cooler air in and over a forest may, at least to a slight extent, affect the passing air currents, especially if these are warm and dry, perhaps increasing the tendency to form local fogs, dew, or even light rain over and to leeward of the forest, provided the existing conditions are already favorable. It has even been held by some that when the

process of condensation has been started, it may continue automatically, the liberation of latent heat tending to produce convectional currents.

This perhaps fairly expresses the general view of the average person at this point. However, having seen that the influence of forests upon temperature and upon humidity is so slight, even among the trees, it is unreasonable to expect that the influence upon rainfall over the forest, and especially away from the forest, will be considerable. In the great ascending, damp air masses of a general storm; in the flow of the winds across a mountain barrier; in the active convectional overturning of a summer thunderstorm—what really significant effect can the slightly damper and slightly cooler air of the forest play in the process of producing or determining the amount of the rainfall? We say, "the air over the forest is damper; therefore there will be more rainfall," quite forgetting that the damper air is useless as a source of precipitation unless it is cooled to the dewpoint. Furthermore, this moisture is constantly being carried away by the winds, and distributed through a great mass of air, thereby giving up more and more of whatever rain-producing effectiveness it may have had.

Forests and Rainfall: the Observations and the Difficulties

Whatever may be our personal prejudices, and whatever may be the theoretical considerations in favor of an influence of forests upon rainfall, what we really want is the facts, so far as they are at present available. Obviously, in a scientific study of this problem, the historical method of treatment, previously referred to; all theoretical considerations, and all prejudices, must give way before the results obtained by means of actual observations, made under approved conditions, with accurate instruments. There has been great difficulty in securing absolutely trustworthy observations. Many of the older records are clearly unreliable because of the improper exposure of the rain-gauges, the differences in the elevation or exposure of the instruments being enough to account for all the observed differences in their catch. Some excellent series of observations have, however, been carried on during the past twenty-five years or more in several European countries, by the agricultural and the forest experiment stations. A system of parallel or radial stations has been extensively used, these being located within forests and in the surrounding open country. Simultaneous observations extending over as many years as possible are compared, the greatest care being taken to have the best exposures, and to allow for the effect of the wind on the catch in the gauges.

The proper exposure of rain-gauges is one of the most perplexing problems in observational meteorology. Rainfall has long been known to be very "patchy," that is, there are considerable differences within very short distances. Thus it happens that gauges which are near together and under similar conditions of exposure often record quite

different amounts of rainfall or of snowfall. Further, the catch of a gauge is markedly influenced by the exposure. In the open field, for example, where there is a free sweep of the winds across the top of the gauge, more rain-drops and especially more snowflakes, are carried over the gauge than in a more protected location, where the drops and flakes can fall more nearly vertically. Thus, a gauge in a forest clearing where the wind velocity is somewhat reduced by the trees, ought to record more precipitation than one in the open country, although the actual fall might be identical in the two cases. A difference of a few feet in the elevation of a gauge will also often result in a catch varying considerably in two neighboring gauges. Furthermore, forests affect wind directions, and this also may influence the catch in the gauges. An element of great uncertainty is thus inherent in all the earlier results obtained by observation, and indeed to some extent in the later ones also, but it should be distinctly emphasized that every effort is now made to "correct" the results for just such errors. In the majority of places where parallel stations exist, the gauges in the forest have actually shown an excess over those in the surrounding open country. Whether this is a real excess of rainfall, or only a difference in the catch, is the disputed point.

The Lintzel Case

There are four cases which have been frequently cited as showing an influence of forests upon rainfall. There is the famous Lintzel case, first cited by Müttrich. At Lintzel, on the Luneburg Heath, in Germany, the rain-gauges used to show a rainfall smaller than the average at a number of the neighboring stations. In 1877 a considerable planting of young trees was undertaken around Lintzel, until several thousand acres were covered. As time went on, the rainfall at the Lintzel station (in an open field surrounded by the forest) showed an increase as compared with that of the surrounding stations.[1] There are, however, reasons against accepting these apparently conclusive results at their face value. The probability of error, the chance of discovering which is greatly diminished by the "smoothing" of the generalized results; the failure to make allowance for the protective effect of the increasing tree-growth; a recent change in the location of the rain-gauge; the shortness of the record, and the general variability and uncertainty of rainfall as a whole, are all considerations which, on the best of authority, may be urged on the other side.

The Nancy Case

Then there is the Nancy case, from France. This is a case of four stations (in two pairs), two in the forest and two in the open, within a small area, the altitudes and the general condition of one pair being,

[1] In 1882–86 Lintzel had about 90 per cent.; in 1887–91 it had about 102 per cent.; in 1892–96, about 118 per cent.

as one writer has said, "as comparable as stations can be made." These Nancy results showed, for a period of about twenty-five years, and for the best pair of stations, somewhat more rainfall (about one half inch to one inch in the yearly average) in the forest. In the case of the other pair the excess was much greater. This series of comparative observations was unfortunately discontinued a few years since, and although the available data have been widely used, they are, in the opinion of the leading official meteorologist of France, as expressed in private correspondence with the present writer, inadequate to serve as the basis of a serious study.

The Indian Case

The two cases just cited are in the temperate zone. The other two cases are found within the tropics. There is, first, the case of a district in the central provinces of India, where forest protection and reforestation began in 1875, and where the rainfall, as compared with the rainfall of all India, showed an increase of about 12 per cent. in a comparatively few years. This, again, seemed an unanswerable argument in favor of a forest influence upon rainfall. But the complication due to periodic oscillations of climate, various uncertainties and the possibilities of error in the observations, together with the difficulty of "correcting" the catch, acknowledged by the Indian authorities themselves, have led to a feeling that we ought at least to suspend judgment in this case. Nevertheless, because the effect of wind upon the rainfall catch is less in the tropics than in our own latitudes, and therefore the error arising from the increasing protection afforded by the growing forest is greatly lessened, von Hann (1908), the acknowledged authority in climatological matters, is ready to accept the general result of these Indian observations as evidence in favor of an influence of forests in increasing the amount of precipitation at least in the tropics. Dr. G. T. Walker, however, the present director of the Meteorological Service of India, in a recent study of supposed changes of climate in India (1910), does not find evidence of an effect of forests in increasing rainfall.

The Java Case

Finally, we may cite the Java case, which is without question the most striking of all. This case was studied and first discussed a good many years ago by Professor Alexander Woeikof, of St. Petersburg. The facts as given by him are these: There are extensive dense forests in the south of Java, while the north coast has been largely deforested. A station, Tjilatjap, on the south coast, distant from the mountains, has a mean annual rainfall almost twice as large as that of three stations (Batavia, Tegal, Samarang) on the north coast. The difference is, in round numbers, about 150 inches against 75 inches. The north side is the windward side for the northwest monsoon, and during the

rainy season (December to March) should have more rain than the south, or lee, side. Yet the fact is that there is about the same rainfall on both coasts at that time. During the southeast monsoon the south (windward) side has a much heavier rainfall than the north (leeward), which is normal. On Celebes, where, according to Woeikof, no such deforestation has taken place, the windward and leeward sides have their normal values of rainfall, the former having a notably larger amount. The case is obviously a very striking one. In reply to a letter from the writer, asking whether newer data from Java tended to strengthen or weaken his previous opinion regarding this case, Dr. Woeikof said:

> I have not modified my views on forests and rainfall. . . . It seems to me that in later years at Tjilatjap, on the south coast of Java, which I cited as a station surrounded by forests, the rainfall is smaller than before. This would confirm my views, as in this formerly very little settled part of the island, forests are rapidly disappearing.

The Java case remains, then, on the authority of one of the best-known meteorologists, a striking example of forest influence on rainfall. So striking, indeed, is it that one is tempted to ask what other possible controlling factors are here active in producing this surprising result.

Recent European Studies

The careful observations which have lately been made in Europe by several investigators (Schubert, Hamberg, Schreiber and others) in western Prussia, Posen, Sweden, Saxony, France and elsewhere, have clearly shown that rain-gauges at forest stations, and above the forest crowns, do generally catch somewhat more rainfall than do the gauges at the parallel stations in open country at the same elevations. The excess varies roughly, we may say, between 1 per cent. and at the most 10 per cent. of the annual mean. But leading European authorities are pretty well agreed that when definite allowance is made for the effects resulting from differences of exposure, due to the better protection of the forest gauges, the apparent excess within the forest is reduced, by the probability of error, to a very narrow margin indeed. In some cases the margin disappears entirely. Schubert, for example, found a summer excess in forested areas of about 6 per cent. Of these 6 per cent., 3 per cent. he believes to be attributable to the better protection of the forest gauge, leaving 3 per cent. And 2 per cent. of these remaining 3 per cent. he thinks still liable to an error. This leaves but 1 per cent.

Conclusion Regarding Rainfall

It appears, therefore, that we have as yet no satisfactory or conclusive evidence that forests, at least in our own latitudes, have a significant effect upon the amount of rain *fall*, as distinguished from the amount of the rain *catch* in the gauge. Nor is there direct and unas-

sailable evidence that our forests increase the frequency of precipitation, although some excellent authorities incline to the view that they do. No one can fairly be called unreasonable if he believes that, after making all proper corrections, there remains no appreciable difference in rainfall inside and outside of our temperate zone forests. Perhaps even the slight remaining differences ought themselves to be "corrected" away. On the other hand, no one can be called unduly optimistic who, knowing the many uncertainties involved in any critical study of rainfall records, gives the forest "the benefit of the doubt" and holds that it really does rain a little more over forests than in the open. But the "little" is, at best, very little, as the latest European observations have shown. We can not, if we will, make it an excess of more than a few hundredths of the total annual rainfall. The margin of difference between the two points of view is thus seen to be very slight indeed. One thing is clear. Granting that *all* of the observed differences between the catch within forests and outside of forests is due to an actual difference in rain *fall,* and not largely to the difference in exposure, the excess over the forest still remains but a small proportion of the annual rainfall. In other words, even the uncorrected observations give a maximum value for forest effects which is itself relatively slight. If, at best, forests can only produce such slight differences over and among the trees themselves, we can not suppose that they will have enough effect upon passing air currents to influence the climate of more distant regions. Hellmann has shown that an increase in the rainfall over a forest, resulting from the slackening of the lower air currents and a readier descent of the raindrops, is accompanied by a lessened fall to leeward. Thus there is equalization; simply a slight difference in distribution.

It is not altogether surprising that one writer has expressed the opinion that "no definite and unassailable result can ever be obtained" by means of such forest meteorological observations as those now made in Europe, and that "there would be little to be gained by a further study of the question." Yet this attitude will hardly commend itself to those who are anxious to have the present uncertainty cleared up, so far as possible. In view of what has already been said, it hardly needs to be stated that, in spite of the deforestation, by lumbering and fire, of large sections in the eastern United States, there is no reliable evidence of any decrease in rainfall, nor of any other change of climate. (It is, however, only fair to say that a good deal of this denuded area has been covered by second-growth timber.) Nor, in spite of the prevailing popular impression to the contrary, is there any reliable evidence whatever that cultivation and tree-planting over extended areas of the west and southwest have resulted in any increase in the amount of precipitation. There is, of course, a better conservation of moisture for plant use. We are surely within the bounds of reason when

we say that there is no hope that we can increase our rainfall really appreciably or effectively by any amount of tree-planting. A whole ocean of water can not give rainfall if the general pressures and temperatures and winds are hostile to precipitation.

As was pointed out at the beginning of this paper, forests are of many different kinds. We can not, therefore, reasonably expect all forests to have the same effects. There may be a difference between tropical and temperate forests, as has already been suggested in the case of Java rainfall, for tropical weather types and rainfall conditions are different from our own, just as tropical forests are different from our own. Tropical rainfalls, as over the great forested Amazon valley, are largely thunderstorm rains, and as forests tend to check air movement, and calms are favorable conditions for convectional overturning, it appears as if tropical forests might be expected to influence rainfall more than our own. Furthermore, from the hot and damp tropical forest, and from the leaves of the closely-crowded tropical trees, there must come a large amount of moisture which will increase the vapor content of the ascending air and tend to increase condensation and rainfall. Thus Woeikof, whose emphasis on the case of Java has been referred to, believes that in low latitudes the vast tropical forests do increase the amount of rainfall. Von Hann, the leading authority on climate, holds that we may conclude "with considerable certainty that, at least in the tropics, the forest may increase the amount of rainfall." Hettner, also, in his work in the tropical Cordillera, came to the conclusion that the forests in the Cordillera of Bogotá favor the growth of clouds and the production of rain. While this is an interesting phase of our discussion, we have as yet no thorough study of tropical conditions by means of the parallel station method. There is also another point. In low latitudes, where the dense tropical forests are found, the rainfall is already so heavy that it is of little or no significance whether there is a good deal more, or a good deal less. In exactly those regions, therefore, where, if anywhere, forests may have a really appreciable influence on rainfall, little or no economic importance attaches to the question. Woeikof believes that rain often begins earlier over tropical forests, and in Mauritius, Walter has called attention to the fact that the number of rainy days seems to be greater over forested areas.

It need hardly be pointed out that, if rain is already falling, the opportunity for it to reach the earth's surface must be better if it falls through the somewhat cooler and damper air over a forest or a grass-covered surface than through a hotter and drier stratum of air over a desert. In the latter case the loss by evaporation may be so great that the drops do not reach the surface at all. Obviously, the contrasts between these two conditions are greatest in the case of the tropical forests and tropical deserts. It must, however, be observed that this

effect is one of the conservation of rain already produced without the action of the forest, not a case of an increase of rainfall directly due to the forest.

Another effect of conservation may sometimes be seen when, after a rain, the low clouds ("fog") continue to hang over a forest, and may give another light shower there while no more rain falls over the fields. In this case, the drops left hanging on the leaves evaporate; the air over the forest may become very damp; a slight cooling will suffice to produce a second falling of the same water which fell previously. This is clearly not a case of an increase of rainfall. It is pretty safe to say that it would rain somewhat oftener, and a little more heavily, over tropical deserts if the surface were covered with vegetation instead of being sandy and therefore heated to a high degree, although the cause of the rain is far beyond the action of desert or forest. But tropical deserts are sandy deserts because the general condition of the atmospheric circulation makes them so, not because they have been deforested.

Influence of Forests in Collecting Moisture from Clouds and Fogs

There is one effect of trees, often observable during dense fogs, which results in the collection and precipitation of water drops which would otherwise not fall to the surface. This is a mechanical collection by trees, or it may be by telegraph and telephone wires, or by the rigging on board ship, of the fog or cloud particles carried against the object in question by the moving air. When the amount of water thus collected is sufficient, drops fall from the collector as a gentle shower. Thus there is an actual increase in the amount of precipitation, although no increase in the amount of condensation. Many years ago, Sir John Herschel, during his residence at the Cape of Good Hope, called attention to the fact that, when low clouds were closely overhead, a shower of rain might be experienced under the trees on the side of Table Mountain, whereas no rain fell outside. The explanation which he gave was inaccurate, but the fact was important. Recently, Marloth has shown that the collection of water droplets from the clouds on Table Mountain is an important factor in supplying moisture for the swamps and springs. A rain-gauge with a bunch of grass fastened on wires around its rim, so that the collected water drops would run into the gauge, gave from ten to thirty-five times as much "rainfall" as an ordinary gauge. Further, the number of horse-power furnished by a stream coming down the mountain decreased more than one half after a fire had burned off the vegetation on the top of the mountain. Abbe has called attention to the "steady dripping of trees enveloped in cloud-fog" on the windward side of Green Mountain, on the Island of Ascension. This mountain owes its name to the fact that it is always green with verdure. From its summit comes the principal

water supply for the garrison, this water being contributed partly by "slight showers" and partly by the "steady dripping" just referred to. "Every exposed object," says Professor Abbe, "contributes its drip." Another case, described by William L. Hall, in the Hawaiian Islands, is that of the collection of the drip from the trees in a region of heavy fog (? cloud) in troughs for the use of cattle. In this locality deforestation would, it is stated, "reduce the productiveness of the plantations, if not ruin them entirely."

The present writer has several times, during fogs, noted the dripping of water from the wires above the sidewalks in his own city. The sidewalks being dry at the time, the drops from each wire made a wet line on the pavements. Again, when steaming through the thick fogs on the Grand Banks of Newfoundland, many of us have seen real, though gentle, showers of rain falling from the wet rigging on to the dry decks.

In winter, when the moisture freezes on the trees, the branches and twigs may become heavily covered with "frost." Fischbach has noted the fact that in winters of deficient snowfall in the Black Forest, he has several times observed that the frost shaken off of the trees by the wind has made possible the use of sledges for transporting wood. In one single European case, reported by Wilhelm, the amount of "rainfall" resulting from the occurrence of such a frost deposit on trees was not far below .05 inch.

In this mechanical collection of water particles by a forest, we seem to have a really effective means of increasing the total *fall* of rain. It is easy to see that if such favorable conditions are often repeated, and where the trees are tall and have many branches, the surface of the ground beneath the forest may easily receive a not inconsiderable supply of moisture. Such action on the part of forests is further aided by the fact that fogs often seem to last longer among trees. Nevertheless, we should remember (1) that the conditions favorable to this particular forest influence are found only locally, especially on forested mountain slopes and tops; (2) that the increase in the fall of rain is limited to the area covered by the forest itself, and is, therefore, not upon soil used for agriculture; and (3) that in the European observations, above referred to, this particular action of forests was at work, as well as all other forest influences, yet the results were, as has been seen, uncertain.

Influence of Forests upon Hail and Other Storms

There has been a widespread impression in parts of Europe that hailstorms avoid forests, and that forests serve to break up and to weaken other storms. The evidence on the question of hailstorms is conflicting, but we may say that the popular impression can be explained on the ground that hail naturally does more damage to tender crops

than to forest trees, and that the damage in the former case would attract, in the latter would largely escape notice. Further, as regards storms and high winds in general, forests do, as has been seen, tend to check wind velocity, and thus to reduce the local violence of a gale. On the other hand, however, recent investigations in Germany have shown that in thunderstorms the obliquely descending component of the wind can be but slightly, if at all, affected by forests, whose trees are easily uprooted by these winds.

The Hygienic Influence of Forests

There are several ways in which forests have a hygienic significance, and the location of many of our well-known health resorts in or near extended forest areas is, therefore, well planned and logical. The reduced wind movement; the protection against the severest extremes of summer heat and of winter cold; the marked decrease of dust and of other atmospheric impurities; the grateful shade and lack of glare on sunny days; the relatively small number of microorganisms—all these are helpful, not only to those who are ill or convalescent, but to persons in good health; all these are arguments in favor of wooded parks in and in close proximity to our cities. In addition, but of non-climatic importance, there are the scenic attractions of the forests; the relief from the noise and the bustle of the city; the fragrance of the air among the evergreen trees, and the frequent intermingling of river and lake and mountain, all of which features contribute to the popularity of forest sanitaria and pleasure resorts. So far as the composition of forest air is concerned, there is no further notable difference between it and the air outside. We can not, therefore, look for any marked curative effects on that account. The much-discussed beneficial effects of the ozone in the forest air seem to lack the support of observation.

The Influence of Forests upon Water-supply, Erosion and Floods

The preceding discussion has dealt with the influence of forests upon climate. Therefore no mention has been made of their relation to the conservation of the water-supply, to erosion and to floods, all of which are non-climatic, or at any rate only indirectly climatic effects. There is still a great deal to be learned about the use of forests in connection with water-supplies; their effects in holding back rainfall and in storing the winter snow; their relation to floods, and ground-water, and springs and erosion. The "last word" in this discussion is to be found in the "Final Report of the National Highways Commission" (Sen. Doc. No. 469, 62d Cong., 2 sess., 1912). From this report we take the following statements, which are of peculiar interest, because they represent the conclusions and recommendations which have been reached

after a thorough study of the different phases of this many-sided problem. It is easy to see why different observers, under different conditions, have reached such divergent results.

Whatever influence forests may exert upon precipitation, run-off and erosion, it is evidently greatest in the mountainous regions where the rainfall is heaviest, slopes steepest and run-off most rapid. Here also the land is less useful for other purposes. The extent of the influence of forests upon these three factors varies greatly, according to circumstances involved in each case. Under one set of conditions, forests may benefit stream flow and mitigate floods, while under other conditions they may have the opposite effect. In no case can they be relied upon to prevent either floods or low-water conditions. There is substantial agreement on this point. Nor is their influence extensive enough to warrant their use as the only means of securing the uniformity of stream flow which is desirable for navigation or the development of water power. For this purpose storage reservoirs would be much more effective. The prevention of erosion undoubtedly outweighs all other benefits of forestation and constitutes one of the most necessary phases of conservation. The commission favors the prevention of deforestation of mountain slopes wherever the land is unsuitable for agricultural purposes, and urges the reforestation of those tracts which have already been denuded, not only when located at the headwaters of navigable streams, but wherever this would be the most valuable use of the land. The increasing pressure of population upon subsistence will make it necessary to use for agricultural purposes all land suitable for cultivation. The influence of forests upon stream flow and erosion is not sufficient to warrant their retention except where the land is unsuited for other purposes. Furthermore, it is possible, if correct methods of agriculture are employed, to retain for cultivation areas located on steep hillsides. This has been successfully accomplished in other countries by terracing and by other means. It must be remembered, however, that reforestation alone can accomplish little toward preventing erosion. The prevention of forest fires, the regulation of hillside farming and the prohibition of complete denudation of mountain tracts, where the soil cover is thin and the land unsuited for agricultural purposes, are also necessary. Forests retard the melting of snow in the spring, and, by allowing the water from this source to be absorbed, exercise a beneficial influence upon stream flow, but should heavy spring rains fall upon the snow thus preserved and cause it to melt within a few hours, the effect of the forest is in such a case to aggravate rather than ameliorate flood conditions. It thus appears that under one set of conditions forests may exercise a beneficial influence upon stream flow and floods, while under another their influence will be harmful.

But these problems do not directly concern the climatologist. He is satisfied if he can make clear, as he sees it, the influence of the forest as a control of climate. If his statements are often disappointingly broad and generalized, it is because he has not the needed scientific basis for making them otherwise.

GOETHE AND THE CHEMISTS

By ROY TEMPLE HOUSE
NORMAN, OKLA.

WE learn from "Dichtung und Wahrheit" that when the young Goethe came home ill from the University of Leipzig in 1768, he fell under the influence of a physician who claimed to have found an infallible panacea which he did not dare use because he was afraid of legal action against him. His young patient was suddenly seized with an attack of violent illness which threatened his life, and the physician was persuaded to use his mysterious drug, with the result that the young man at once began to mend and soon recovered. This experience was the beginning of Goethe's infatuation for alchemy, which began fantastically enough—although we have no occasion to quarrel with it when we remember its influence on "Faust" and "Die Wahlverwandschaften"—but became in the course of time a serious and profitable interest in chemical investigation. Although he was never a thoroughly grounded chemist himself, his marvelous skill in forming mutually profitable partnerships with specialists made his chemical activity of real and great significance.

Established at Weimar as an official member of the government, he early made friends with the interesting court apothecary, Wilhelm Heinrich Sebastian Buchholz. This gentleman had studied medicine and received his medical degree, but after leaving school had devoted himself to pharmacy and had bought what was then the only apothecary-shop in Weimar. He was a prosperous and jovial man of the world and played an important part in the social life of the little capital, but he was none the less a genuine scientist, and Goethe's debt to him was a considerable one, as he himself admits in the narrative entitled "Geschichte meines botanischen Studiums" which closes the "Metamorphose der Pflanzen." Buchholz kept up a large garden which contained, we are told, "not only the herbs which he needed for his business, but rare and newly discovered plants." He seems to have kept himself well informed as to new discoveries and developments in his own and related sciences, and when the Montgolfier brothers sent up their balloon from Avignon in 1783, Buchholz tried a similar experiment at Weimar; but Goethe wrote his friend Knebel, describing the first attempt: "He torments the air in vain; the balls refuse to rise." His later efforts seem to have been crowned with success, to the astonishment of the multitude and the distress of the pigeons; and Goethe,

delighted with this and later flights which he witnessed in Cassel, seems to have finally reached the point of performing the feat himself. He worked also with Buchholz at the analysis of water and its purification by the use of powdered charcoal; and the pharmacist remained until his death, which occurred in 1798, an active and honored member of Goethe's celebrated "Freitaggesellschaft."

A brother of Goethe's friend Friedrich Hildebrand von Einsiedel had studied mining and metallurgy, secured the title of *Bergrat* (counsellor of mines) and established a laboratory in Weimar. Goethe appears to have visited him frequently, but we learn of nothing in the way of genuine additions to the world's knowledge that developed from his labors. Current references to him indicate that he occupied himself largely with marvelous chemical exhibitions for lady visitors; and Wilhelm Bode describes him as a man of natural gifts, who, "although he knew more about chemistry, geology, even of the history of countries and races, than all the masters, doctors, scribes and priests," nevertheless accomplished nothing of serious importance. In 1785 he was sent to North Africa by the French government to study mining conditions there, and Goethe mentions the enterprise several times in his letters; not, however, so much for its scientific importance as because of the fact that he took with him one of the most prominent lady members of Weimar Court society, after she had succeeded in spreading the report of her death and had had a dummy buried in her place. On his return, he gave up his scientific investigations, and Goethe purchased his apparatus for his fosterling, the University of Jena; so that in spite of his lack of energy, August von Einseidel played a very essential part in the scientific activity of the Duchy of Weimar, after all.

One of the assistants of the talented apothecary Buchholz was a young Saxon, Friedrich August Göttling, who was destined to surpass his master. The son of a poor minister, beginning life as an apothecary's assistant, he published in 1778 an "Introduction to Pharmaceutical Chemistry," and so interested Goethe that the latter made it possible for him to study at Göttingen from 1784 till 1787, and to travel and observe industrial conditions in Holland and England. Shortly after his return his powerful patron secured his appointment to a professorship at Jena, where he was very profitably active for many years. Göttling will be remembered longest for his part in the phlogiston discussion. It was about 1700 that Stahl promulgated his theory that combustion involved a loss of substance. Although Lavoisier (1743–1794) proved conclusively that burning is oxidation, *i. e.*, an addition instead of a subtraction, German chemists of Göttling's time, partly perhaps for patriotic reasons, still clung to the exploded theory, and Göttling, who published between 1794 and 1798 a "Contribution toward the Justification of Antiphlogistic Chemistry," stood almost alone among

his countrymen in his views on this question. It is true that he was not entirely free from the influence of the old method of reasoning, as is shown by the fact that he tried to explain the burning of phosphorus in nitrogen—which of course occurred only because he did not in that day have instruments which made it possible to exhaust all the oxygen —by the assumption of a new and mysterious substance which was in itself the essence of light and heat.

He and Goethe worked together at the extraction of sugar from beets and at other enterprises, and Goethe was his regular and faithful student as well as his colleague and his patron. The great poet became an enthusiastic champion of the new chemistry, and published in Schiller's "Musenalmanach" in 1797, an epigram which ran:

> Schon ein Irrlicht sah ich verschwinden, dich Phlogiston! Balde,
> O Newtonisch Gespenst, folgst du dem Brüderchen nach.
> (Will o' the Wisp, Phlogiston, I see thou hast vanished. And shortly
> Newton's vague specter shall flee; flee as his brother has fled.)

But even Goethe's eloquent fulminations were not powerful enough to banish the Newtonian specter.

After Göttling's death Goethe continued to interest himself in the chemist's widow and little son. The latter, Karl Wilhelm Göttling, became librarian and professor of philology at Jena, and was later to repay in some measure his old patron's kindness to himself and his father, by assisting in preparing the complete edition of his works.

Dr. Alexander Nikolaus von Scherer, born in Russia in 1771, was recommended to Goethe in 1797 by Wilhelm von Humboldt. The poet furnished the newcomer a laboratory and equipment, and both he and Duke Karl August took the warmest interest in him. He made some interesting discoveries with phosphorus, and from 1798 he edited in Jena the *Allgemeine Journal der Chemie*. He died in Russia in 1824, a member of the St. Petersburg Academy.

One of Scherer's assistants in the conduct of the *Journal* was the somewhat younger Johann Wilhelm Ritter, a Silesian, who came to Jena penniless in 1795. He entered the university, and at once attracted general attention by his scientific aptitude. Ritter made some discoveries of great value. He discovered the chemically active dark rays in the solar spectrum, and accomplished some interesting results with galvanism. He obtained hydrogen and oxygen by disorganizing water with the electric current, he decomposed sulphate of copper, and he constructed a "charging pile" which was a precursor of the modern accumulator. Goethe studied and worked with him a great deal, especially during the years 1800 and 1801. He was inclined to be somewhat speculative and mystical, and especially after his call to the University of Munich in 1804, he gave himself up to various lines of fantastic theorizing. He became deeply interested in animal magnetism,

experimented with divining rods for the location of minerals and water below the surface, and developed a theory of siderism that for a time enjoyed considerable notoriety. His writings continued to exert an influence over Goethe, and their effect is traceable in the latter's novel "Die Wahlverwandschaften."

But the most notable of all Goethe's chemical helpers was the young Bavarian, Johann Wolfgang Döbereiner. The son of poor parents, this young man secured education enough to become a pharmacist's assistant, and even came so far at one time as to own a small establishment of his own. But the fates seemed working against him. Although he had published a number of monographs which had made him nationally known, it seemed for a time as if he would be unable to gain even the most meager living for himself and his family. In 1810 he was penniless and unable to secure the humblest position as an apothecary's assistant, when Duke Karl August and Goethe, whose attention had been attracted to him by his publications and who were confident that he would be competent and useful in spite of his irregular education, called him to Jena to replace the deceased Göttling.

This was the beginning of a long and useful period of forty years at Jena, ending only with his death, although in the course of his activity there he received at least five more favorable offers from other institutions. His was a faithful, affectionate nature, and he felt such gratitude to his Weimar patrons for having come to his assistance at the time of his greatest need that he refused to leave on any terms. He showed his idealistic turn of mind very strikingly at other points. Although he is responsible for several inventions which have great industrial value, he always refused—and in this matter Goethe was heartily at one with him—to impose any restrictions on their use, but threw them open to the world and allowed others to reap the profits. He was always ready to give free advice to industrials, and made large fortunes for others, while he himself was struggling along on the utterly inadequate salary which was all his little university was able to spare him.

Döbereiner did useful work in stoichiometry and atomic measurements; as Gay-Lussac had established the laws of proportion in inorganic chemical compounds of gases, so the young German was able to develop the proportions for organic compounds. His discussions "On Pneumatic Chemistry" were valuable additions to the chemistry of gases in general. His measurements of the amount of carbonic acid gas which escapes in the alcoholic fermentation of sugar and the publications which he based on the data thus obtained, extended knowledge of a process which Lavoisier had already established in a general and partially only theoretical fashion. In 1829 appeared his "Attempt at a Grouping of the Elements according to their Analogy." Here occurred for the first time the celebrated arrangement into triads—chlorine, bromine, iodine,

etc. It was too early for his assertions with regard to atomic weights to be verified, but it is surprising how nearly accurate his system was.

Döbereiner, between the years 1820 and 1830, made some remarkable discoveries with platinum. He heated the double chloride of platinum and ammonium to a glow and obtained what he called platinum sponge. He found that this light, porous substance, when slightly warmed and placed in contact with alcohol, becomes red hot, and that if it is set in a mixture of hydrogen and oxygen, it grows hot without the application of heat from without. He drove hydrogen against a piece of the platinum sponge surrounded by atmospheric air, and found that the platinum was heated and the hydrogen ignited by the process. He found also that metallic platinum, in contact with hydrogen gas, causes it to unite with oxygen to form water. These experiments excited attention and admiration throughout the chemical world. The great Swede Berzelius termed his discoveries "the most brilliant of the generation," and the most celebrated of Döbereiner's pupils, Runge, the discoverer of aniline, ranked his master as "the most famous of living chemists."

We have said that a great deal of Döbereiner's work has industrial importance. He saw how to derive acetic acid from alcohol, and he was able to hasten the process of vinegar formation by the help of powdered platinum. He applied his discovery of the ignition of hydrogen by contact with platinum sponge, to the construction of an instrument called the "Döbereiner igniter," which enjoyed great popularity until it was superseded by friction matches. But this quality of platinum is still utilized in gas tips and in the manufacture of sulphuric acid.

Döbereiner experimented with the possibilities of coal-gas for illuminating purposes, obtaining his gas by the action of steam on coal at a very high temperature; and he was the first to discover the usefulness of the mixture of hydrogen and carbonic oxide called "water-gas." There has been some discussion on this point, but a letter of Goethe's dated December 5, 1819, proves that Döbereiner had studied the mixture seven years before a process for the production of water-gas was patented in England.

The poet and the chemist were faithful correspondents, and we have sixty-five letters of Goethe to Döbereiner and five of those written by the chemist in return, which prove that they were on very intimate terms. The two would spend entire days together in the laboratory at Jena, and other days together in Weimar, where Goethe maintained a laboratory especially equipped for his friend's use. We have a poem of Goethe's dedicated to the scientist on the occasion of the latter's birthday, and we find again and again that the chemist's patron tried to

secure an increase in salary and better equipment for his faithful friend and helper. It was due to Goethe's influence that Döbereiner was nearly or quite the first chemistry professor in Germany who was able to give practical as well as theoretical class instruction in his subject.

Döbereiner made mistakes which are traceable to Goethe's influence. The two were certain, for example, that electricity is the source of life, and this belief led to some strange and quaint theories which smack a little of the old days of alchemy. Both were inclined to undervalue equipment, and to look upon the fields and the hills as an adequate laboratory. But on the whole, Goethe gave as much and as usefully as he took. Alexander von Humboldt had said that the immortal poet-philosopher's views of natural phenomena had " elevated him, equipped him as it were with new organs." And Döbereiner showed his gratitude not only in words, but in every tangible way that came within his reach. He was always ready to give time and thought to assisting his master wherever his talents made him useful, from the preparation of a tooth powder to the deciphering of a Latin epigram of the old poet Antonius dealing with a poison and an antidote—an epigram which was absolutely dark to the scholars, but became light as day with the help of the chemist.

Döbereiner was the youngest of the famous Weimar group, and many years after the death of the great chief and center of that group, the old Jena scientist found his greatest pleasure in telling the younger generation of the golden age of German intellectual activity.

THE DOMESTICATION OF AMERICAN GRAPES

By Professor U. P. HEDRICK
AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.

THERE are about forty species of grapes in the world, more than half of which are found in North America. Few other plants on this continent grow wild under such varied conditions and over such extended areas. Thus, wild grapes are found in the warmer parts of New Brunswick; on the shores of the Great Lakes; everywhere in the rich woodlands and thickets of the North and Middle Atlantic States; on the limestone soils in the mountainous parts of Kentucky, Tennessee and the Virginias; and they thrive in the sandy woods, sea plains and reef-keys of the South Atlantic and Gulf States, where a single vine of the Scuppernong often clambers over trees and shrubs for a hundred feet or more. While not so common west of the Mississippi, yet some kind of wild grape is found from North Dakota to Texas; grapes grow on the mountains and in the canyons of all the Rocky Mountain States; and several species thrive on the Mexican borders and in the far southwest, where they furnished the early Spanish *padres* with grapes for wine and suggested the planting of the first vineyards in America.

While it is possible that all of the native grapes have descended from an original species, the types are now as diverse as the regions they inhabit. The wild grapes of the forests have long slender trunks and branches whereby their leaves are better exposed to the sunlight. Two shrubby species do not attain a greater height than four or five feet; these grow in sandy soils, or among the rocks well exposed to sun and air. Another runs on the ground and bears foliage almost evergreen. The stem of one species attains a diameter of nearly a foot, bearing its foliage in a great canopy; from this giant form the species vary to sorts with slender, graceful, almost delicate, climbing vines. Wild grapes are quite as varied in climatic adaptations as in structure of vine, and grow luxuriantly and bear fruit in almost every condition of heat or cold, wet or dry, capable of supporting fruit-culture in America. So many of the kinds have horticultural possibilities that it seems certain that some of them can be domesticated in all of the agricultural regions of the country, their natural plasticity indicating, even if it were not known from experience, that all can be domesticated.

Leif the Lucky, the first European to visit America, if the Icelandic records be true, christened the new land Wineland after its grapes. Captain John Hawkins, who visited the Spanish settlements in Florida in 1565, mentions the wild grapes among the resources of the New World, with the statement that the Spaniards "had made twenty hogs-

heads of wine in a single season." Amadas and Barlowe, sent out by Raleigh in 1584, described the coasts of the Carolinas as, "so full of grapes that in all the world like abundance can not be found." Captain John Smith, writing in 1606, describes the grapes of Virginia and recommends the culture of the vine as an industry for the newly founded colony. Few, indeed, are the explorers of the Atlantic seaboard who do not mention grapes among the plants of the country. Yet none saw intrinsic value in these wild vines. To the Europeans the grapes of the Old World alone were worth cultivating and the vines growing everywhere in America only suggested that the grape they had known across the sea might be grown in the new home.

During colonial times and the first half century of the union, efforts to grow European varieties of grapes in America were continuous. Some of the experiments were on a large scale and in the hands of expert vine growers, yet all resulted in failure. Several large companies undertook grape-growing and wine-making in the years following the Revolution; the efforts of a few of these are worth noting.

Peter Legaux, a Frenchman, founded a company to grow grapes at Spring Mill, near Philadelphia, in 1793. John James Dufour, a Swiss, came to America in 1793 to engage in grape-growing and became the head of the Kentucky Vineyard Society in the valley of the Ohio in Kentucky and Indiana. The Harmonists, a religious-socialistic community, planted ten acres of grapes about 1805 near Pittsburgh, and later made another plantation at New Harmony, Indiana. When the Napoleonic wars were over, a number of Bonaparte's exiled officers came to America and founded the Vine and Olive Colony on land granted them by Congress on the Tombigbee River in Alabama. Here one hundred and fifty French settlers spent several years in vain attempts to grow European grapes in America. In a rough and hardly explored country, part of which was overflowed half the year, with all the sickness inherent to such a location, unaccustomed to field work and the hardships of a new country, the attempt to grow grapes, where failure was predestined because of natural obstacles, became for these French officers and their families a tragedy which ended in great suffering and the impoverishment of all and the death of many.

It is only on the Pacific coast and in favored valleys of the Rocky Mountains that *Vitis vinifera,* the grape of the Old World, can be grown. The great viticultural industry of California is founded upon the successful culture of this species. The native grapes can be grown, but they can not compete on the Pacific coast with the Old World grape for any purpose. The success attained in the cultivation of this species west of the continental divide makes all the more remarkable its complete failure east of the divide.

For three centuries from the first recorded attempt to grow the Old World grapes in America, the causes of the failures were a mystery.

As one of the first experimenters stated, "a sickness takes hold of the vines and they die." The agent causing the sickness is the phylloxera, a tiny plant louse, undiscovered until the last half of the nineteenth century, which works on the leaves and roots of the European grapes, but which does comparatively little harm to American species. Undoubtedly, the resistance of native grapes to the phylloxera is due to natural selection in the contest that has been going on for untold ages between host and parasite. Three other pests, black-rot, downy mildew and powdery mildew, are destructive to European grapes in America. The climate, too, in eastern North America alternates between hot and cold, wet and dry, and the Old World grapes grow well only in equable temperatures and conditions of humidity. The leaves of the Old World grape are thin and soft and the roots fleshy; the leaves of the American species are thick and leathery and the roots hard and fibrous. These differences in the structure of the species of *Vitis* explain their adaptations to the two climates.

That American viticulture must depend upon the native species for its varieties began to be recognized at the beginning of the nineteenth century, when several large companies engaged in growing foreign grapes failed, and a meritorious native grape made its appearance. The vine of promise was a variety known as the Alexander. Thomas Jefferson, ever alert for the agricultural welfare of the nation, writing in 1809 to John Adlum, one of the first experimenters with an American species, voiced the sentiment of grape experimenters, in speaking of the Alexander:

> I think it will be well to push the culture of this grape without losing time and efforts in the search of foreign vines, which it will take centuries to adapt to our soil and climate.

The Alexander is an offshoot of the common fox grape, *Vitis labrusca*, found in the woods on the Atlantic coast from Maine to Georgia and occasionally in the Mississippi Valley. The history of the variety dates back to just before the Revolutionary War, when, according to William Bartram, the Quaker botanist, it was found growing in the vicinity of Philadelphia, by John Alexander, gardener to Governor Penn of Pennsylvania. Curiously enough, it came into general cultivation through the deception of a nurseryman. Peter Legaux, mentioned before, in 1801 sold the Kentucky Vineyard Society fifteen hundred grape cuttings, which he said had been taken from an European grape, introduced from the Cape of Good Hope, therefore, called the "Cape" grape. Legaux's grape turned out to be the old Alexander. In the new home the spurious "Cape" grew wonderfully well and as the knowledge of its fruitfulness in Kentucky, Ohio and Indiana spread, demand for it increased and with remarkable rapidity, considering the time, it came into general cultivation in the parts of the United States then settled.

Of the several species of American grapes now under cultivation,

Vitis labrusca, first represented by the Alexander, has furnished more cultivated varieties than all the other American species together, no less than 500 of its varieties having been grown in the vineyards of the country. There are several reasons why it is the most generally cultivated species. It is native to the parts of the United States in which agriculture soonest advanced to a state where fruits were desired. In the wild, the Labrusca grapes are the most attractive, being largest and handsomest in color—among all grapes it alone shows black, white and red-fruited forms on wild vines. There is a northern and a southern form of the species and its varieties are therefore widely adapted to climates and to soils. The flavor of the fruits of this species, all things considered, is rather better than that of any other of our wild grapes, though the skins in most of its varieties have a peculiar aroma, somewhat pronounced in the well-known Concord, Niagara and Worden, which is disagreeble to any who are accustomed to the pure flavors of the European grapes. Unfortunately few varieties of this species are adapted to wine-making, as the fruits lack both sugar and acid and impart to wines an unpleasant aroma and taste. All varieties of *Vitis labrusca* submit well to vineyard operations and are vigorous, hardy and productive, though they are more subject to the dreaded phylloxera than are most of the other cultivated native species.

Of the many grapes of the *labrusca* type, at least two deserve brief mention.

The Catawba, the first American grape of commercial importance, is the most interesting variety of its species. The origin of the variety is not certainly known, but all evidence points to its having been found about 1800 on the banks of the Catawba River, North Carolina. It was introduced into general cultivation by Major John Adlum, soldier of the revolution, judge, surveyor, and author of the first American book on grapes. Adlum maintained an experimental vineyard in the District of Columbia, whence in 1823 he began the distribution of the Catawba. At that time the center of American grape culture was about Cincinnati, and an early shipment of Adlum's Catawbas went to Nicholas Longworth, grandfather of the present bearer of that name, and was by him distributed throughout the grape-growing centers of the country. As one of the first to test new varieties of American grapes, to grow them largely and to make wine commercially from them, Nicholas Longworth is known as the "father of American grape culture."

The Catawba is still one of the four leading varieties in the vineyards of eastern America. The characters whereby its high place is maintained among grapes are: great elasticity of constitution, by reason of which it is adapted to many environments; rich flavor, long-keeping quality, and handsome appearance, qualities which make it a very good dessert grape; high sugar content and a rich flavor of juice, so that

from this grape is made a very good sweet or dry wine, the latter entering into a blend for nearly all of the champagne produced in eastern America. The vines, too, are vigorous, hardy and productive. The characters of Catawba are readily transmissible and it has many pure-bred or hybrid offspring which more or less resemble it.

The second commercial grape of importance in American viticulture is the Concord, which came from the seed of a wild grape planted in the fall of 1843 by Ephraim W. Bull, of Concord, Massachusetts. The new variety was disseminated in the spring of 1854, and from the time of its introduction the spread of the culture of this grape was phenomenal. By 1860 it was the leading grape in America and so remains. It furnishes, with the varieties that have sprung from it, seventy-five per cent. of the grapes grown in eastern America. The characters which distinguish it are: adaptability to various soils, fruitfulness, hardiness, resistance to diseases and insects, certainty of maturity and attractive appearance. It is produced so cheaply that no other grape can compete with it in the markets. It is, as Horace Greeley well denominated it in awarding it the Greeley prize for the best American grape, "the grape for the millions."

Long before the northern fox grapes had attained prominence in the vineyards of the north, the Scuppernong had been partially domesticated in the south. It is a variety of *Vitis rotundifolia,* a species which runs riot from the Potomac to the Gulf, thriving in many diverse soils, but growing only in the southern climate and preferring the seacoast. The Scuppernong has been cultivated somewhat for its fruit or as an ornamental from the earliest colonial times. It is certain that wine was made from this species by the English settlers at Jamestown. Vines of it are now to be found on arbors, in gardens, or half wild on fences in nearly every farm in the South Atlantic States. That the *rotundifolia* grapes have not more generally been brought under cultivation is due to the bountifulness of the wild vines, which has obviated the necessity of domesticating them. The fruit of its varieties, to a palate unaccustomed to them, is not very acceptable, having a musky flavor and odor and a sweet, juicy pulp, which is lacking in sprightliness. Many, however, acquire a taste for these grapes and find them pleasant eating. The wines from *Vitis rotundifolia* partake too much of the muskiness of the fruit unless blended with those of other species. The great defect of this grape is that the berries part from the pedicels as they ripen and perfect bunches of grapes can not be had—in fact, the crop is often harvested by shaking the vines so that the berries drop on sheets beneath. Despite these defects a dozen or more varieties of *rotundifolias* are now under general cultivation in the cotton belt and interest in their domestication is increasing.

The south has another grape which, while not so early brought under domestication or now so generally grown, has greater horticultural pos-

sibilities than *Vitis rotundifolia.* This is *Vitis æstivalis,* the summer grape, or, to distinguish it from the *rotundifolias,* the bunch grape of southern forests. The *æstivalis* grapes are preeminent in wine-making in eastern America. The wines from this species make the best red wines, usually of the claret and Burgundy types, to be had from American vines. A defect of these grapes is that they contain an excess of some of the necessary elements which make good wines; as color, tannin, acidity and bouquet, but these faults are easily remedied by blending. There are now a score or more well-known varieties of *Vitis æstivalis,* of which the best known is Norton, which probably originated with Dr. D. N. Norton, of Richmond, Virginia, in the early part of the nineteenth century. The berries of the true *æstivalis* grapes are too small, too destitute of pulp and too tart to make good dessert fruits. Domestication of this species has been greatly retarded by a peculiarity of the species which hinders in its propagation. Grapes are best propagated from cuttings, but this species is not easily reproduced from cuttings and the difficulty of securing good young vines has been a serious handicap in its culture.

There are two sub-species of *Vitis æstivalis* which promise much for American viticulture. *Vitis æstivalis bourquiniana,* known only under cultivation and of very doubtful botanical standing, furnishes American viticulture several valuable varieties. Chief of these is the Delaware, the introduction of which sixty years ago from the town of Delaware, Ohio, raised the standard in quality of our grapes to that of the Old World. No European grape has a richer or more delicate flavor or a more pleasing aroma than the Delaware. While a northern grape it can be grown in the south and thrives under so many different climatic and soil conditions and under all is so fruitful that, next to the Concord, it is the most popular American grape for garden, vineyard and wine-press. Without question, however, the Delaware contains a trace of European blood.

Another offshoot of this sub-species is the Herbemont, which in the south holds the same rank that the Concord has in the north. The variety is grown only south of the Ohio, where it is esteemed by all for a dessert grape and for its light red wine. It is one of the few American varieties which finds favor in France, being cultivated in southwest France as a wine grape. Its history goes back to a colony of French Huguenots in Georgia before the Revolutionary War. Very similar to the Herbemont is the Lenoir, also with a history tracing back to the French in the Carolinas or Georgia in the eighteenth century.

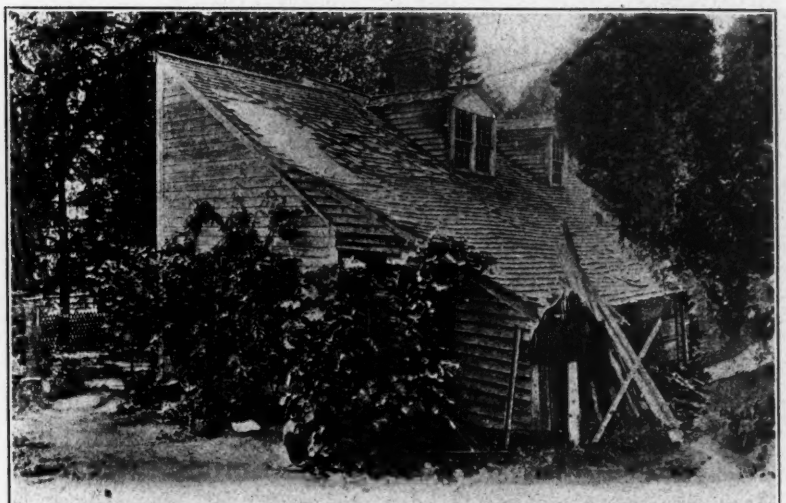
The other sub-species of *Vitis æstivalis* is *Vitis æstivalis lincecumii,* the post-oak grape of Texas and of the southern part of the Mississippi Valley. Recently this wild grape has been brought under domestication and from it have been bred a number of most promising varieties for hot and dry regions.

As agriculture becomes more diversified in the south, when cotton and tobacco no longer hold complete sway, the varieties of *Vitis æstivalis* and its two sub-species will become important agricultural assets.

The north, too, has a wine grape from which wines of their types nearly equalling those of the southern *æstivalis* are made. This is *Vitis riparia,* the river grape, the most widely distributed of any of the native species. It grows as far north as Quebec, south to the Gulf of Mexico, and from the Atlantic to the Rocky Mountains. Fully a century ago a wine-grape of this species was cultivated under the name Worthington, but the attention of vineyardists was not turned to the *riparias* until after the middle of the last century, when the qualities of its vines attracted the attention of French viticulturists. Phylloxera had been introduced from America into France and threatened the existence of French vineyards. After trying all possible remedies for the scourge it was discovered that it could be overcome by grafting the European grapes on American vines resistant to the phylloxers. A trial of the promising species of New World grapes showed that the vines of *Vitis riparia* were best suited for the reconstruction of French vineyards, being not only resistant to the phylloxera, but also vigorous and hardy. It is interesting to note that a large proportion of the vines of Europe, California and other grape-growing regions are grafted on the roots of this or of other American species and the viticulture of the world is thus largely dependent upon these grapes.

The French found that a number of the *riparia* grapes introduced for their roots were valuable as direct producers for wines. The fruits of *Vitis riparia* are too small and too sour for dessert, but they are free from the disagreeable tastes and aromas of some of our native grapes and therefore make very good wines. The best known of the varieties of this species is the Clinton, which is generally thought to have originated in the yard of Dr. Noyes, of Hamilton College, Clinton, New York, about 1820. It is, however, probably the Worthington, of which the origin is unknown, renamed. There are possibly a hundred or more grapes now under cultivation wholly or in part from *Vitis riparia,* most of them hybrids with the American *labrusca* and the European *vinifera,* with both of which it hybridizes freely.

A curious fact in the domestication of all these species is that they did not come under cultivation until forms of them striking in value had been found. Catawba, representing the *labrusca* grapes; the Scuppernong, the *rotundifolias;* Norton from *Vitis æstivalis;* the Delaware and Herbemont from the *Bourquiniana* grapes; and Clinton from *Vitis riparia,* are, after a century scarcely excelled, though in each species there are many new varieties. It is with grapes as with all fruits; the majority of the best varieties originate by chance and for the reason that a prodigious number of natural seedlings, pure or cross-bred, arise, and natural selection, while wasteful, is wonderfully effective.



The Bull House, Home of the Concord Grape

That our best grapes have come from chance is not because of a lack of human effort to produce superior varieties. Of all fruits the grape has received most attention in America from the generation of plant-breeders just passing. Their product is represented by fifteen hundred varieties, a medley of the more or less heterogeneous characters of a dozen species. That these have not excelled is due more to a lack of knowledge of plant-breeding than to a lack of effort. Now that order and system, undreamed of a generation ago, have been disclosed by the brilliant discoveries in plant-breeding of the last decade, future efforts to improve grapes ought to be more fruitful than those of the past.

As early as 1822, Nuttall, a noted botanist, then at Harvard, recommended "hybrids betwixt the European vine and those of the United States which would better answer the variable climates of North America." In 1830 William Robert Prince, fourth proprietor of the then famous Linnean botanic nursery at Flushing, Long Island, grew ten thousand seedling grapes "from an admixture under every variety of circumstance." This was probably the first attempt on a large scale to improve the native grapes by hybridizing, though little seems to have come of it. Later a Dr. Valk, also of Flushing, grew hybrids from which he obtained the Ada, the first named hybrid, the introduction of which started hybridizers to work in all parts of the country where grapes were grown.

Soon after Valk's hybrid was sent out, E. S. Rogers, of Salem, Massachusetts, and J. H. Ricketts, of Newburgh, New York, began to give viticulturists hybrids of the European *vinifera* and the American species which were so promising that enthusiasm and speculation in grape-growing ran riot. Never before nor since has grape-growing received the attention in America given it during the decade succeeding the

SHOOT OF *Vitis labrusca*, THE NORTHERN FOX GRAPE, THE MOST WIDELY CULTIVATED OF OUR NATIVE GRAPE.

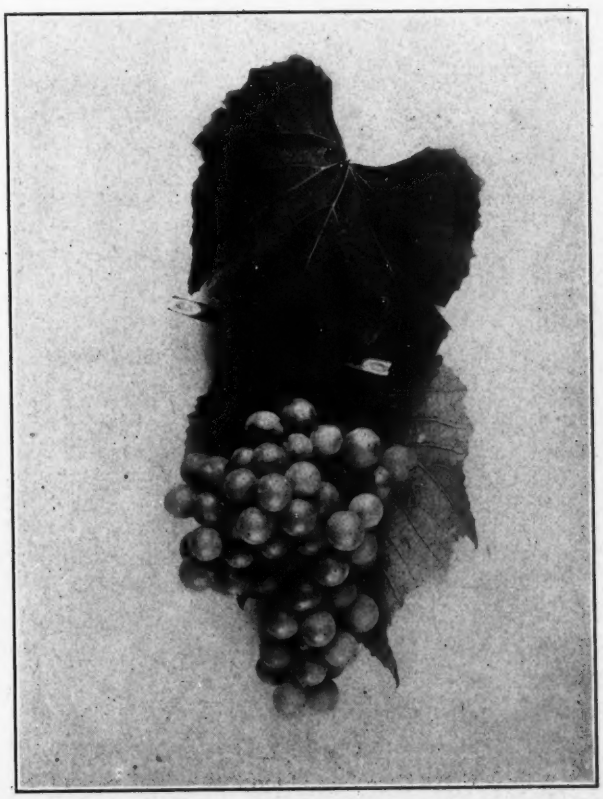
introduction of Rogers' hybrids. It was the golden era for nurserymen. One of the grape propagators of that time tells of carrying, during this boom, a thousand dollars' worth of plants on his back from the nursery to the express office. It was the expectation of all that we were to grow in America, in these hybrids, grapes but little inferior, if at all, to those of Europe.

A statement of the difference between European and American grapes shows why American viticulturists are so eager to grow either purebreds from the foreign grape or hybrids with it.

European grapes have a higher sugar and solid content than the American species; they, therefore, make rather better wines, excepting champagnes, and keep much longer after harvesting and can be made into raisins. So, too, they have a greater variety of flavors, which are more delicate, yet richer, with a pleasanter aroma, seldom so acid, and are always lacking the disagreeable, rancid odor and taste, the "foxiness," of many American varieties. There is, however, an unpleasant astringency in some of the *vinifera* grapes and many varieties are without character of flavor. American table grapes, on the other hand, are more refreshing, the unfermented juice makes a pleasanter drink, all of the grape juice of the markets being made from native grapes, and,

lacking sweetness and richness, they do not cloy the appetite so quickly. The bunches and berries of the *vinifera* grapes are larger, more attractive, and are borne in greater quantities. The pulp, seeds and skins are somewhat objectionable in all of the native species and scarcely so at all in *Vitis vinifera*. The berries of the native grapes shell from the stems so quickly that the bunches do not ship well. The vines of the Old World grapes are more compact in habit and require less pruning and training than do those of the native grapes, and, as a species, probably through long cultivation, they are adapted to more kinds of soil, to greater differences in environment, and are more easily propagated than the American species.

Because of these points of superiority in the Old World grape, since Valk, Allen and Rogers showed the way, American grape-breeders have sought to unite by hybridization the good characters of *Vitis vinifera* with those of the American grapes. Nearly half of the fifteen hundred grapes cultivated in eastern America have more or less *vinifera* blood in them. Yet despite the efforts of breeders few of these hybrids have commercial value. Whether because they are naturally better fixed, or long cultivation has more firmly established them, the vine



LEAF AND FRUIT OF A WHITE CULTIVATED LABRUSCA.

SHOOT OF *Vitis rotundifolia*, THE SCUPPERNONG OR SOUTHERN FOX GRAPE.

characters of *Vitis vinifera* more often appear in varieties arising as primary hybrids between the *vinifera* grapes and the native species, and the weaknesses of the Europeans, which prevent their cultivation in America, crop out. Hybrids in which the *vinifera* blood is more attenuated, as secondary or tertiary crosses, give better results.

Several secondary hybrids now rank among the best of the cultivated grapes. Examples are the Brighton and the Diamond. The first is a cross between Diana-Hamburg, a hybrid of a *vinifera* and a *labrusca*, crossed, in its turn, with the Concord, a *labrusca;* the second is a cross between Iona, also a hybrid of a *vinifera*, and a *labrusca* crossed with the Concord. Both were grown from seed planted by Jacob Moore, of Brighton, New York, in 1870. The Brighton was the first secondary hybrid to attract the attention of grape-breeders and its advent marked an important step in breeding grapes.

The signal successes achieved by the hybridizers of the European grape with the native species quickly led to similar amalgamations among the American species. Jacob Rommel, of Morrison, Missouri, beginning work about 1860, hybridized the *labrusca* and *riparia* grapes

so successfully that a dozen or more of his varieties are still cultivated. All are characterized by great vigor and productiveness, and, though they lack the qualities which make good table grapes, they are among the best for wine-making. Rommel has had many followers in hybridizing the native species, chief of whom is Mr. T. V. Munson, Denison, Texas, who has literally made every combination of grapes possible, grown thousands of seedlings, and produced many valuable varieties.

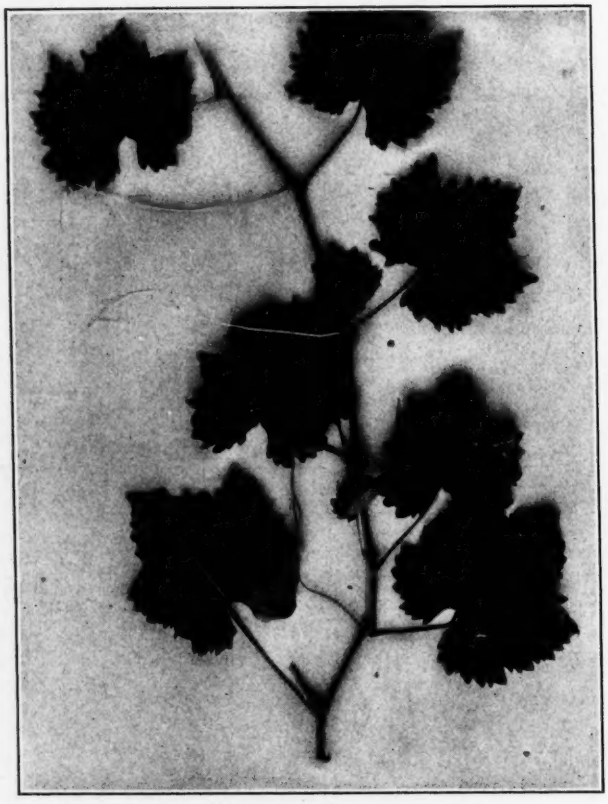
The aim of hybridization in breeding plants is to combine the desirable and eliminate the undesirable characters of varieties or species in a new race. A plant, however, is such a complex sum-total of characters that no one can predict with any certainty the result of mingling the characters of two more or less distinct plants. Speculation thus quickens the charm of hybridization. The progeny of crossed grapes is always chaotic and must be passed through the sieve of selection, the meshes of which have grown larger and larger with use until now out of thousands of new forms a grape-breeder will retain few indeed.

Within the last decade, hybridizing has received a great impetus through the publication of Mendel's experiments. In the past hybridization has been a maze in which breeders lost themselves. Mendel's discovery in heredity assures a regularity of averages and gives a definiteness and constancy of action hereto wholly unknown in hybridization. It now appears that many of the characters of grapes follow

SHOOT OF *Vitis æstivalis*, THE SOUTHERN WINE GRAPE.

the law discovered by Mendel, and with this as a solid basis and the brilliant methods of Mendel for example, the further domestication of the species of this fruit ought to go forward in leaps and bounds.

Selection, continued through successive generations, so important in the improvement of field and garden plants, can play but small part in the domestication of the grape. The period between planting and fruiting is so long that progress would be slow indeed were this method



SHOOT OF *Vitis vinifera*, THE EUROPEAN GRAPE.

relied upon. Moreover, selection, as a method in breeding, is possible only when plants are bred pure, and it is the experience of grape-breeders that in pure breeding this fruit loses in vigor and productiveness and that the variations are exceedingly slight and unstable. Many pure-bred grapes have been raised on the grounds of the New York Agricultural Experiment Station under the eyes of the writer, of which very, very few have surpassed the parent or have shown promise for the practise of selection.

From present knowledge it does not appear probable that new characters are produced in plants by hybridizing. New varieties so origi-

nating are but recombinations of the characters in the parent—the combination is new but not the characters. Thus one parent of a hybrid grape may contribute color, size, flavor and practically all of the characters of the fruit and the other parent vigor, hardiness, resistance to disease and in general the characters of the vine. Or, of course, these and the other items in the make-up of the grape may be intermingled in any mathematically possible way. New characters probably appear as variations, and of these plant-breeders now recognize two kinds.

Nothing is more certan than that all offspring differ from their parents in many details—individual variation. Plant-breeders have long believed that by selecting desirable variations we have an efficient means of improving plants just as evolutionists have held and many continue to hold that evolution goes forward by means of natural selection from these variations. But there is a new school, headed by the Dutch botanist, De Vries, who believe that these variations do not produce anything new, but that they always oscillate around an average, and if removed from this for a time, they show a tendency to return to it. Whether the orthodox Darwinians or the De Vriesians are right does not matter here. The point is that the fluctuating variations of individuals, upon which Darwin chiefly founded his principle of natural selection, cut but a small figure in the breeding of grapes. It is not certain that such variations are heritable, nor whether they are capable of cumulative increase generation after generation, and, besides, as we have seen, selection must be consistent and persistent for too long a while to make it effective with grapes.

Evolution and plant-breeding have taken a fresh start through the recent amplification by De Vries of the theory that marked changes take place in plants through mutations, or characters which arise in a plant at once, with a single leap, and are stable from the time they arise. If this theory hold for grapes, it may be that there is a possibility of absolutely new characters arising in this fruit. It is well known that bud-sports, which in most cases must be called mutations, now and then arise in grapes. But these mutations have not as yet played an important part in producing new varieties. Not more than two or three of the fifteen hundred sorts now under cultivation are suspected of having arisen in this way. Until the causes of these mutations are known and they can be produced and controlled, but little can be hoped for in the amelioration of grapes through mutations.

Hybridization, then, has been and continues to be the chief means of domesticating grapes. "Fluctuations" and "mutations," produced other than by hybridizing, are too vague as yet for the grape-breeder to lay hands on. Even should the theory of De Vries be true, that nothing new—in the strict sense of the word—comes except through mutations, with more than a score of species of grapes, each with manifold distinct characters, all capable of fluctuating variations, there are many

surprises in store for lovers of grapes in the new varieties that may be produced by hybridizing.

Whatever method of improvement is followed very much depends upon the immediate parentage. Some varieties, whether self-fertilized or crossed, produce much higher averages of worthy offspring than others. There is so much difference in varieties in this respect that to discover parents so endowed is one of the first tasks of the grape-breeder. Unfortunately, no way is known of discovering what the best progenitors are except by records of performance. The reasons for this prepotency, seemingly well established in plants and animals alike, are not well explained by present knowledge. Often varieties of high cultural value are worthless in breeding because their characters seem not to be transmitted to their progeny, and to the contrary a variety good for but little in the vineyard may be most valuable from which to breed.

What are the results of a century's work in domesticating the wild grapes of America?

There are approximately in eastern America at the present time 240,000 acres of grapes, the product of which is largely sold for dessert purposes, but from it is manufactured yearly in the neighborhood of 10,000,000 gallons of wine, of which about 1,000,000 gallons are champagne. The making of grape juice, an industry possible only with native grapes, has grown so rapidly that it is hard to estimate the output, but certainly not less than 2,000,000 gallons were sold in the markets last year. It is doubtful if any other cultivated plants at any time in the history of the world has attained such importance, in so short a time from the wild state, as our native grapes.

Fifteen hundred varieties from twelve of the native species of grapes are now under cultivation. Almost every possible combination between these species has been made; they have been so mixed and jostled that species can no longer be recognized in the majority of varieties and the future breeder must work with characters rather than species. The methods of the past in domesticating the native grapes have been wholly empirical and extremely wasteful. Many have been called, but few chosen. But with the new knowledge of breeding and with the experience of the past, domestication ought to proceed with greater certainty. It is not too much to say that in this immense country, with its great differences in environment, we shall, some time, everywhere be growing grapes and of kinds so diverse that they will meet all of the purposes to which grapes are now put and the increasing demands for better fruits made by more critical consumers.

UNITED STATES PUBLIC HEALTH SERVICE[1]

By ALFRED C. REED, M.D.

ASSISTANT SURGEON, UNITED STATES PUBLIC HEALTH SERVICE

THE wide-spread ignorance of the various means employed by the federal government to promote the well-being of its citizens is nowhere better exemplified than in the common ignorance of the functions and important work of the Public Health Service. This ignorance is the more lamentable inasmuch as the Public Health Service is the sole national agency operating to combat and prevent epidemic diseases among human beings, and to improve public sanitation and hygiene, in the United States. The awakening national conscience in public health affairs lends peculiar interest at this time to a consideration of the varied and important functions exercised by this service, and the fascinating history of its achievements.

The Marine Hospital Service is one of the oldest and most peculiarly American of all our institutions. Its beginning was in an act of congress of July 16, 1798, which put a tax of twenty cents a month on every seaman of the United States, to be taken from his wages. The occasion for this procedure had been well explained by Hon. William Williamson in the House of Representatives away back in 1792.

> Wherever it is probable that sailors may be sick, there I would make provision for their support and comfort. Hospitals should be erected or lodgings hired at every port of entry in the United States, for sick and infirm seamen, where they may be properly attended during their indispositions. The money to be collected at the several ports as hospital money should be expended in those same ports alone, under care of such a person as may be designated for that purpose.

The first hospital owned by the government was at Washington's Point, Norfolk County, Virginia. This was purchased in 1800. Three years later a Marine Hospital was completed at Boston. At about the same time, the money collected by taxation of seamen was transformed into a general fund for medical relief work among sailors. The same legislation made provision for the establishment of the service in New Orleans, which was not then a part of the United States.

After a time the seamen's tax was not sufficient to maintain the constantly broadening work, which had to be correspondingly restricted in its usefulness. No chronic or incurable diseases were treated, nor was any patient kept longer than four months. Sailors in those days fared poorly, and their life was a hard one indeed. Especially was this true on the Mississippi River system, which was a great water-highway

[1] The author is indebted to Surgeon George W. Stoner, Chief Medical Officer at Ellis Island, for many facts concerning the earlier history of the Public Health and Marine Hospital Service.

HYGIENIC LABORATORY, U. S. PUBLIC HEALTH SERVICE, WASHINGTON, D. C.

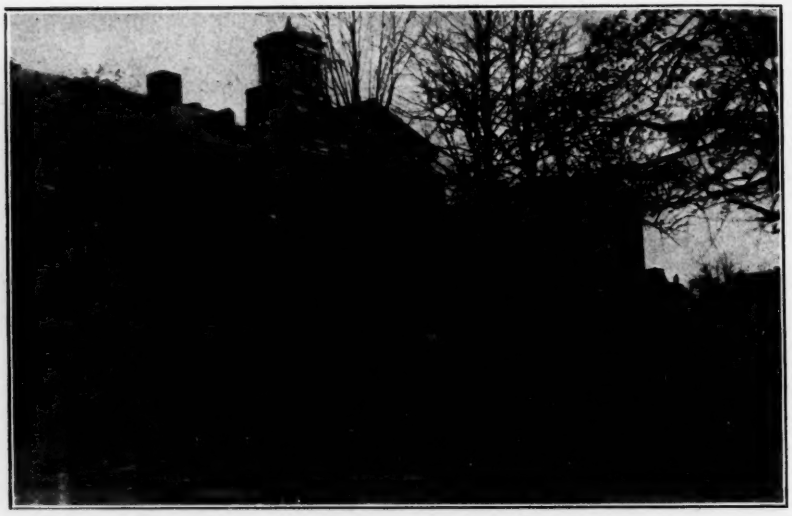
and the principal means of commerce and communication over a vast territory. Often a flatboat starting from the upper river would lose its entire crew of five or six men by disease before reaching New Orleans. During the severe cholera epidemic of 1832 and 1834 the lot of the rivermen was especially severe.

It became necessary for congress to assist the service work by annual appropriations. In 1837 the original Marine Hospital was built in New Orleans and provision was made for purchasing sites for hospitals in three inland zones. Along the Mississippi River stations were located at Natchez, Miss.; Napoleon, Ark., and St. Louis, Mo. On the Ohio, the chosen points were Paducah, Louisville and Pittsburgh. The center for the Lake Erie sailors was at Cleveland. The first Marine Hospital at Chicago dates from 1848 and was built on land adjacent to old Fort Dearborn. The second hospital, the present one, was authorized in 1864 and opened for patients in 1873. It occupies a beautiful location on the lake shore five miles north of the harbor.

The first service establishment on the Pacific Coast, at San Francisco in 1851, was on the contract basis. A hospital was erected three years later, a commodious and well-built structure, doomed to serious injury in the severe earthquake of 1868. The contract system with other hospitals was then resumed and continued until the completion of the present building in 1875. During the Civil War many marine hospitals in both the north and the south were converted into military hospitals. Those at Boston and Norfolk were used in this capacity in the war of 1812.

In 1870 congress reorganized the service and Dr. John M. Woodworth, of Illinois, was appointed supervising surgeon. Within the next three years, the service began to attract considerable attention in foreign countries. London medical journals bestowed lavish praise on this uniquely American institution. At this time service officers were requested by the supervising surgeon to inform themselves fully as to local health regulations and to assist, when requested, in their enforcement.

Upon Dr. Woodworth's death in 1879 President Hayes appointed Dr. John B. Hamilton to succeed him. The year before Dr. Woodworth's death marked the occurrence of a terrible epidemic of yellow fever in the Mississippi Valley. With this freshly in mind, congress added quarantine control to the growing functions of the Marine Hospital Service, but failed to make any appropriation for its operation. Then a year later, in 1879, a law was passed creating a National Board of Health to exercise quarantine functions for four years. At the end of that period, the law of 1878 was revived, and national quarantine passed permanently into the hands of the Marine Hospital Service. The entire development of the quarantine service took place under the wise guidance of Dr. Hamilton.



MARINE HOSPITAL, STATEN ISLAND, N. Y.

In June, 1891, Dr. Hamilton resigned to be succeeded, by the appointment by President Harrison, of Dr. Walter Wyman, who had been chief of the quarantine division in the administrative bureau. In 1902 the enlarging and changing functions exercised, necessitated a change in name from the old Marine Hospital Service to the cumbersome but expressive Public Health and Marine Hospital Service. In 1893 additional quarantine powers were added and additional responsibilities imposed, such as the medical inspection of immigrants. In 1875 the supervising surgeon became the supervising surgeon general, and was commissioned. By the legislation of 1889 commissions were conferred on all the regular officers of the corps. The old seamen's tax was finally abolished in 1884 and since then the service has been supported entirely by Congressional appropriation.

Examinations are held annually at Washington for candidates for admission to the corps. No more rigorous test is to be found for any medical appointment than this, lasting from a week to ten days or more. The examination covers the physical condition, literary and academic preparation, and practical and theoretical training. It includes a practical laboratory and hospital bedside examination. After four years assistant surgeons are eligible to be examined for promotion to the next grade of passed assistant surgeon. After from fifteen to twenty years' service, further examinations are held for promotion to the grade of surgeon. There are now 135 commissioned officers. This service offers one of the most attractive openings in the country for young physicians.

The splendid institution known as the Hygienic Laboratory, now recognized the world around for its excellent contributions to the knowledge of scientific medicine and of public health and sanitation,

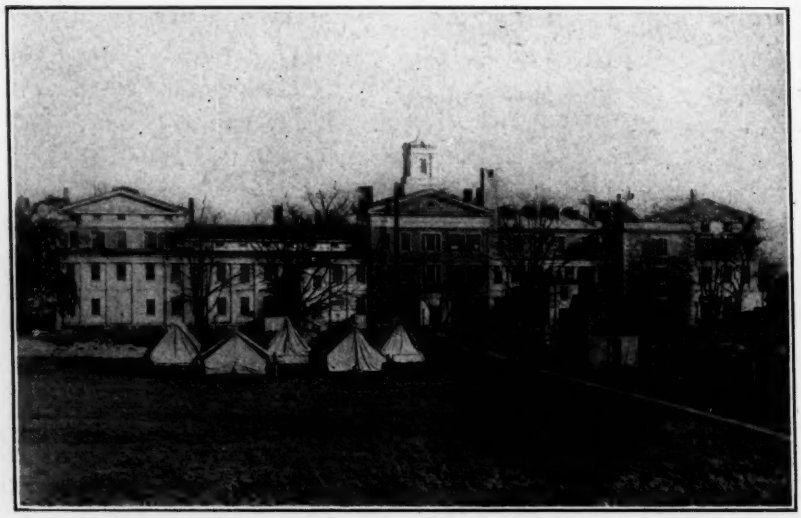
was founded just twenty-five years ago as a laboratory of pathology and bacteriology in the old marine hospital at Stapleton, Staten Island. At first all of the work was done by one officer in the intervals of his attendance in the hospital wards. After four years the work was transferred to Washington, where it has been ever since, and until 1894 was housed on one floor of the service office building. About this time the advantages began to be realized of using this laboratory as a training school for officers, supplemented with details abroad affording opportunity for visiting the great centers of London, Paris, Berlin, Vienna and other cities.

Among the earlier subjects taken under consideration were disinfecting methods as applied to quarantine and epidemic practise. These investigations resulted in the elaboration of a system of disinfecting apparatus, together with disinfecting agents and a method for their application, which now stands unrivaled. This laboratory was probably the first to recommend formaldehyde in place of the older disinfectants, steam, carbolic acid and sulphur dioxide. The first authoritative publication on the use of diphtheria antitoxin was issued by the Marine Hospital Service, and the first diphtheria antitoxin made in the United States was produced in the Hygienic Laboratory. Both resulted from personal instruction received by an officer from Behring and Roux, who had separately announced their discovery at a meeting of the International Congress of Medicine at Budapesth.

In March, 1901, congress appropriated $35,000 for the necessary buildings, and directed the cession of five acres of land from the old naval observatory site by the secretary of the navy for the use of the Hygienic Laboratory. After the legislation of July, 1902, which increased the functions of the Marine Hospital Service and changed its name to the Public Health and Marine Hospital Service, the scope, or-

CHICAGO MARINE HOSPITAL.

ganization and personnel of the laboratory were greatly extended. An advisory board was created, consisting of officers from the Army and Navy Medical Corps, a scientist from the Bureau of Animal Industry of the Department of Agriculture, and five men from civil life, who were to be skilled in laboratory work bearing on public health problems. These five at present are Victor C. Vaughan, dean of the School of Medicine of the University of Michigan; William Welch, professor of pathology at Johns Hopkins University; Frank Wesbrook, professor of pathology at the University of Minnesota; Simon Flexner, of the Rockefeller Institute; and William T. Sedgwick, professor of biology at the Massachusetts Institute of Technology.



REAR OF STAPLETON MARINE HOSPITAL, SHOWING TENTS FOR TUBERCULOSIS PATIENTS.

Three additions were made to the original divisions of pathology and bacteriology. These were medical zoology, chemistry and pharmacology. Medical zoology embraces the study of parasitic diseases of man. Under pharmacology, drugs are examined as to purity, potency and action, and important work is done on the standardization of drugs. By another act of July, 1902, provision was made for the licensing of all establishments engaged in interstate traffic in viruses, serums, toxins, antitoxins and analogous products. Samples of such products are bought in the open market and tested for purity and strength. The manufacturing establishments are inspected by medical officers, both before and after the license is granted. Fines and suspensions or withdrawal of license are the penalties for false labeling or faulty methods of production.

The laboratory makes a practise of assisting health officers of states and communities which have no reliable laboratory facilities, by analyzing samples of water, as to impurities, infection and potability. In-

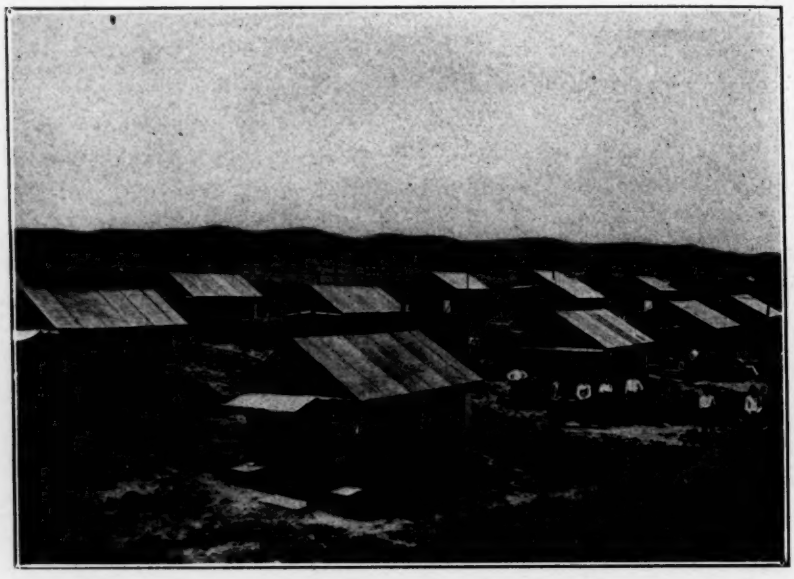
vestigation has likewise been made of the hygiene and sanitary arrangements of railroad coaches and sleeping cars. The question of the dissemination of malaria by mosquitoes has been another productive field of research.

Closely connected with lines of work already outlined, is that of the leprosy investigation station on Molokai, Hawaii. Here, with unlimited material at their disposal, the director and his able assistants are making careful studies of the lepra bacillus, with the ultimate ambition of producing some means for the prevention and cure of the disease. A good example of the thorough and painstaking study of epidemic disease which characterizes the service work, is the exhaustive research made by Stiles of the distribution and results of hookworm infection in the south and especially in the rural sandy districts of Georgia and Florida. What Stiles did for the south, Ashford and King did for Porto Rico, and the result has a large economic, social and sanitary value in both places.

Relief stations of the service are divided into four classes. The first-class stations, numbering 23, consist of a marine hospital under the command of a commissioned officer. Among these is included the tuberculosis sanatorium at Fort Stanton, N. M. After the subjugation of the Apache Indians, the old army post at Fort Stanton, which for forty years had been a frontier protection for ranchmen, was no longer necessary, and in 1896 it was abandoned. For three years the post was deserted, except for the wild desert prowlers, and sagebrush and decay replaced the busy military life which had known it so long. In 1899 the property was acquired by the Public Health and Marine Hospital Service, and again the martial spirit took possession, and once more the stars and stripes floated over the parade ground, fanned by the health-bearing breeze of the New Mexican plateau. But the foe to be conquered under the new régime was not the fierce red warrior whose merciless and invincible spirit had been supreme against the Spaniard and the American for three hundred years. The new foe, more deadly and terrible by far than the old, was the silent and merciless white death, the relentless destroyer of thousands, the plague of tuberculosis.

In situation Fort Stanton is admirably adapted to its present purpose. At an altitude of 6,200 feet, it has winter snows, and moderate heat in the summer. The reservation includes about forty-five square miles, and has resources which, when fully developed, will go far toward making the institution self-supporting. Natural water power is available. Two thousand cattle can be pastured on the range, which now supports almost that number of beef cattle, besides a large dairy herd. Poultry raising will soon supply an abundance of turkeys, chickens and eggs, and hog raising is another industry which promises much.

The daily number of patients averages about two hundred, under the care of seven medical officers. Sixty attendants find employment



TUBERCULOSIS CAMP

on the reservation. No unimportant function of the sanatorium is that which finds its result in the influence of the education in hygiene and tuberculosis prevention, upon those who leave after having been cured or benefited by the treatment. These men spread their new-found knowledge among their associates and so extend the actual good accomplished.

Patients come to Fort Stanton largely from sailor boarding houses and other crowded districts of the large sea ports. Some are old incurable cases, but their lives are prolonged and made more comfortable, and incidentally the Sanatorium is in effect a quarantine station, not in restraining men from liberty, but in that it keeps from the large centers of population a daily average of over two hundren consumptives who in all probability would have continued as sources of infection to innumerable others.

Over half the cases admitted have been returned to active life either cured or near enough cured to resume their occupations.

Outside of Fort Stanton, the larger marine hospitals are located in New York, Chicago, San Francisco, Boston, Detroit, Buffalo and New Orleans.

The second-class stations are under the command of commissioned officers, but have no hospital accommodations of their own. Patients are kept in private or other hospitals, under the exclusive professional care of the medical officer, and the government pays for the hospital facilities under a definite contract. Third-class stations are under the charge of contract acting assistant surgeons, and patients are cared for under government contract with local hospitals. All other relief stations come under the fourth class. Certain of these have a contract surgeon in charge, but have no hospital facilities available. and the

FOR SUMMER, FORT STANTON.

functions of the others are exercised by the Collector of Customs at the place.

Persons entitled to the benefit of medical relief from the Public Health Service are those employed on board in the care, preservation or navigation of any registered or licensed vessel of the United States, or in the service on board of any so engaged.

Officers and crews of vessels in the service of the Mississippi River Commission are included with those entitled to marine hospital relief. This commission has to do with the engineering and inspection of the Mississippi levees, and the removal of snags and obstructions to shipping. Its concern is to maintain the navigability of the Mississippi and its larger branches.

The Revenue Cutter Service, the Army Engineering Corps, together with keepers and surfmen of the Life-Saving Service, are all beneficiaries, as well as the men of the Light House Service, including light ships. A provision not generally known is that foreign seamen may utilize the Marine Hospital accommodations, if written security is given for the payment of the small fees fixed by the department, by the master of the vessel or the consul of the nation under whose flag the vessel sails. In the year ending June 30, 1911, a total of 52,209 patients were treated at the various relief stations of the service, of whom 15,442 received hospital care. At the Fort Stanton Sanatorium, 322 consumptive patients were under treatment.

A large number of physical examinations of seamen in the various government services are necessary, as of candidates for entrance, for promotion and for retirement. Such examinations are conducted by

OFFICERS' QUARTERS, FORT STANTON, NEW MEXICO.

Marine Hospital Service officers for the Revenue Cutter, Coast-Survey, Life-Saving and Lighthouse Services. Instruction is given, when properly applied for, in methods of resuscitation of persons apparently drowned. Applicants for a pilot's license are examined as to their hearing, color perception and visual acuity. The total of such physical examinations for the last fiscal year was 4,610.

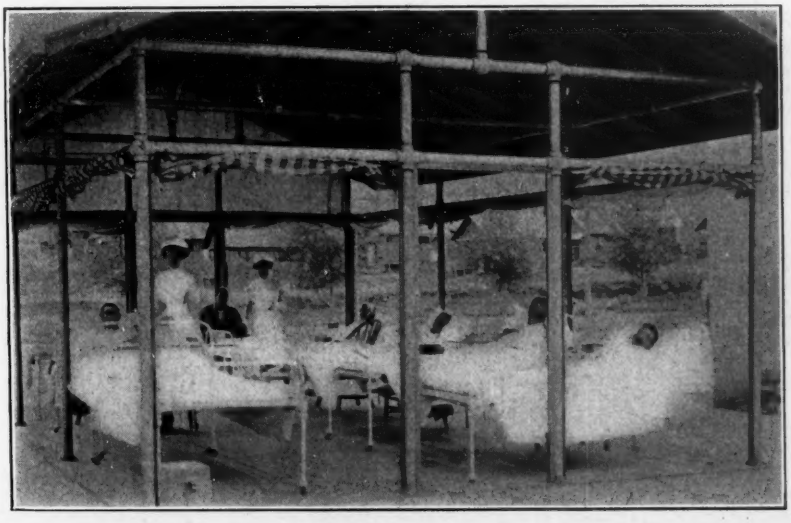
There are many foreign details filled by service officers besides their varied and extensive activities at home. The American consulates have medical officers attached in Yokohama, Habana, Guayaquil, Naples and Hong Kong. Contract surgeons are kept at the principal ports of China, Russia, Japan, India, Italy, Mexico and tropical America. Eight United States Revenue Cutters have a medical officer on board. Through all these various and widely separated posts, information is constantly being collected and collated as to health conditions all over the world. This information is issued in the Public Health Bulletins published weekly by the Bureau of the Public Health Service in Washington. Service officers are detailed to attend certain congresses and conventions on scientific and medical lines, in this country and abroad, and many exhibits are prepared for scientific and popular conventions, of an educative nature and illustrative of the service work.

No more important feature of national health protection can be named than the quarantine service. The history of quarantine measures takes us back to the time of the Milanese and Lombardians, late in the fourteenth century. At that period the great and lucrative Italian commerce had been responsible for the introduction of the black plague from the Levant into Europe and terrible fear was on all the people. Persons coming in with the plague were taken into the midst of large fields and left alone to recover or die as best they could. The penalty for disobedience of the stringent rules was death and confiscation of the victim's property. In 1475 Venice established a Sanitary

Council of three nobles, who were directly charged with preventing the entry of epidemic disease. The Council constructed lazarettoes on two islands, and instituted a rigid inspection of incoming crews, and the letters of health from the place of departure. The time of detention was forty days (quarante diei), hence our term quarantine. Venice was therefore the first to practise systematic quarantine. Similar arrangements were adopted by other countries, and have developed into our modern institution of quarantine. The first quarantine disregarded humane and medical considerations, for the sake of commerce. The latest quarantine disregards commerce but only if it stands in the way of public health and real humanity.

Quarantine stations are maintained at forty-five points of entry into the United States, besides eight stations each in Hawaii, Porto Rico and the Philippines. The quarantine control of the Canal Zone is also exercised by the Public Health Service. A fully equipped quarantine station has adequate provision for boarding and inspecting vessels, apparatus for mechanically cleansing them, and suitable equipment for disinfection with steam, sulphur, formaldehyde and various solutions. It must include a clinical laboratory, hospitals for contagious and doubtful cases, a steam laundry, detention barracks for suspects, bathing facilities, a crematory, sufficient supply of good water and a proper system for the disposal of sewage.

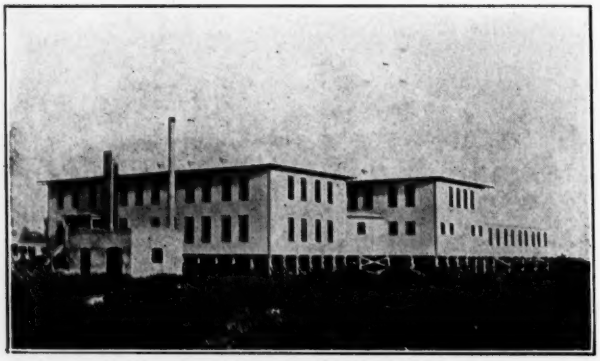
Vessels from domestic ports are also subject to quarantine, if quarantinable disease prevails in the port of their departure, or if there is sickness on board. No persons other than quarantine and customs officers, and pilots, are permitted to board vessels subject to quarantine, until they have been given free pratique. In case a vessel carrying immigrants develops quarantinable disease in transit, after



BED SHELTER, HOSPITAL ANNEX, FORT STANTON.

the full quarantine regulations have been satisfied, the health officers of the several states to which the immigrants are bound are notified of the circumstances that they may keep close supervision to detect any later development of the disease.

Those vessels are placed in quarantine which have had quarantinable disease on board in transit or which the inspecting officer considers to be infected, also vessels arriving during the summer months from tropical American ports, which are not known to be free from yellow fever. Vessels in quarantine may have no direct communication with any person or place outside, and no communication of any nature except



IMMIGRATION STATION, PELICAN ISLAND, GALVESTON, TEXAS.

under the supervision of the officer in charge. The persons detained from such a vessel are divided into small isolated groups, and inspected twice daily by the physician. No intercourse is allowed between these groups. No convalescents are discharged from quarantine until free from infection, and whenever possible this is determined by bacteriological examination.

The United States quarantine regulations provide for inspection of but six diseases, yellow fever, typhus fever, bubonic plague, leprosy, smallpox and cholera. A few facts relative to these will make plain the nature of the special precautions necessary to exclude them.

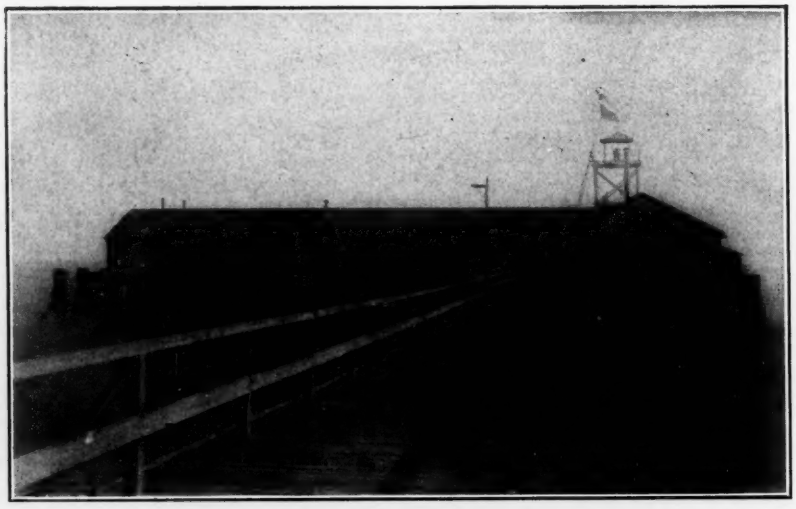
Yellow fever is the great sanitary curse of the tropical Americas. It is an acute non-contagious fever of unknown causation. Its extreme fatality is shown by a death rate which varies from 1 to 95 per cent. The causative agent, whatever it may be, is found in the patient's blood and is transferred to others by one agency alone, a certain type of mosquito, *Stegomyia fasciata.* The area where yellow fever is endemic corresponds exactly with the geographical distribution of the *Stegomyia.* It was due to the magnificent work of the Army Yellow Fever Commission in Cuba in 1898 that responsibility for the spread of the disease was definitely laid to the rôle of this mosquito. Too much honor can not be paid to those brave physicians who risked their lives to discover a

means of checking this yellow scourge and above all to Drs. Walter Reed and Lazear, whose lives helped to pay the price for the knowledge which finally vanquished yellow fever. Their associates on the board, Drs. Carroll and Agramonte, as well as Dr. Finlay, of Havana, are no less deserving of praise. The work of the Army board completed the excellent pioneer work of Surgeon Henry R. Carter on the incubative period of yellow fever. It follows that yellow fever can only be successfully combated by destruction of the mosquitoes by means of which it spreads. Quarantine measures against the disease are therefore concerned with isolation of all cases and very careful exclusion of every possible contact with mosquitoes by screening and elimination of all breeding places.

Cholera presents an entirely different picture from the standpoint of quarantine. Here we have a disease proved to be caused by an intestinal infection with a definite and characteristic microbe, the so-called "*comma*" *vibrio* of Koch. The infection is limited absolutely to the intestinal tract, consequently the entire danger of spread of the disease is limited to the alvine discharges. The bacteria are taken into the system chiefly through the ingestion of infected drinking water, the contamination having arisen from sewage infection or other polluting contact with infected intestinal discharges. Uncooked vegetables and fruits are a secondary source of danger for like reasons. Preventive measures must also be extended to exclude articles of diet such as fresh fruits, for instance, which may tend to excite a tropical diarrhea and so produce a point of lowered resistance where the cholera germs can take effect. Quarantine measures, therefore, aim to isolate all frank cases and suspects, and to detain all who have been exposed, in small groups under close observation for at least five days, covering the incubation period of cholera. Water and food supply must be above suspicion of carrying the germs, and strict cleanliness of person and quarters must be strictly enforced. It is absolutely essential that intestinal discharges from frank cases and suspects alike be thoroughly disinfected. Before convalescent cases are released from detention the intestinal discharges must be proved free from cholera germs by microscopical examination and bacteriological culture.

Smallpox is more familiar than the diseases just described, as are also the circumstances embodied in its quarantine control. Vaccination or proof of immunity by having had the disease are required of all persons exposed, which, of course, means all on board an infected vessel.

Typhus fever, the old time "ship" or "famine" fever, is very rare now in the United States, probably because of improved ship hygiene and sanitation, conditions always inimical to the disease. The last epidemics in this country were in Philadelphia in 1883 and in New York in 1891–92. Very rarely is a case seen at quarantine, but it is controlled by isolation, and disinfection of articles and quarters exposed to infection. Drs. Anderson and Goldberger, of the Hygienic Labora-



DISINFECTING WHARF, TAMPA QUARANTINE STATION, FLORIDA.

tory, have recently proved the identity of typhus and "Brill's disease," a disease fairly often seen in large cities. They have also shown the rôle of the body louse in transmitting typhus. The isolation period for suspects is fourteen days.

No more terrible epidemic has ever threatened this country than bubonic plague and against the entry of no disease are more rigid precautions taken. It exists constantly in oriental countries, especially in China and India, and the great danger of introduction here always confronts us. There are several forms of plague, of which the pneumonic type is the most deadly. This was the prevailing type in the recent epidemic in northern China. The bacillus of plague lives and multiplies in the blood of the victim. It also causes an epizootic in rats and certain other rodents, and from these, as well as from human cases, the bacilli are carried to human victims through the agency of fleas and bedbugs. In addition pneumonic plague is highly infectious directly, spreading from man to man by aerial convection. It is very easily seen how important is the eradication of plague epizootic among rats, ground squirrels and other rodents as is being done now in California. An epizootic is a powder magazine waiting only for the match of proper local conditions to explode in all directions in an epidemic of the greatest virulence.

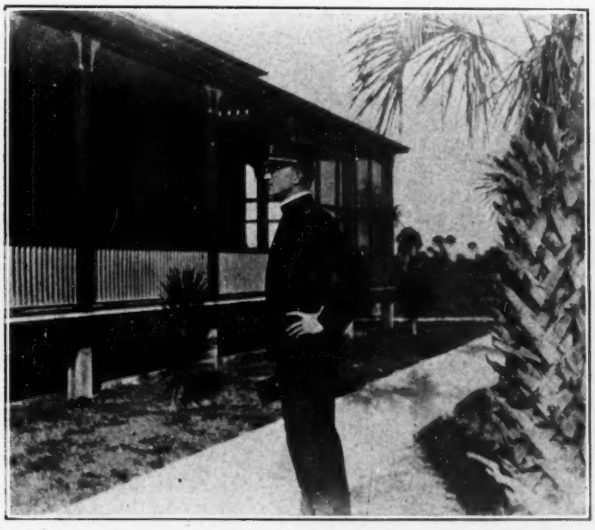
Quarantine measures against plague first of all aim to prevent infected cargo, baggage or ballast from being shipped. To this end rat guards are used, all suspicious articles going on the vessel are thoroughly disinfected and special efforts are made to destroy all rats on board. Cases of plague reaching a domestic quarantine station are isolated and the surroundings and belongings thoroughly disinfected.

A period of fifteen days must elapse after the last possible exposure before release of suspects.

Leprosy is only mildly contagious, at least in this country, and is an instance of a disease made quarantinable more because of its loathsome nature and the abhorrence in which it is popularly held than because of actual infective danger from it. The immigration law absolutely excludes all alien lepers. Others must be removed from vessels at quarantine, and the quarters disinfected.

No small feature of the activity of the Public Health Service is its conduct of the medical examination of immigrants. No argument is necessary to convince every thoughtful patriot of the vital importance of this work. The immigration laws are explicit, and while the medical examiners have no authority to pass judgment on the admissibility of aliens, they have the basic function of supplying medical evidence against mental and physical defectives, which evidence under the law has a determining influence with the inspectors of the Immigration Bureau of the Department of Commerce and Labor. The methods of medical inspection of incoming aliens and laws concerned, have been discussed and described by the author elsewhere,[2] and will not be taken up here.

By far the largest port of entry for immigrants is through Ellis Island, N. Y. During the year ending June 30, 1911, 749,642 aliens were inspected there, as against a total of 303,007 for all other points of entry combined. At Ellis Island are stationed 23 medical officers,



QUARTERS AT TAMPA, FLA.

[2] "Medical Aspects of Immigration," THE POPULAR SCIENCE MONTHLY, April, 1912; "Going through Ellis Island," THE POPULAR SCIENCE MONTHLY, January, 1913.

DETENTION BARRACKS, MARIVALES QUARANTINE, PHILIPPINE ISLANDS.

and a larger force would be able to do even better work. The immigrant hospital on Ellis Island during the year mentioned cared for 5,141 aliens, in addition to 720 cases of acute contagious disease which were transferred to the State Quarantine Hospital at the entrance to the harbor pending completion of the present excellent contagious disease hospital on Ellis Island. There is possibly no place in the United States where a similar variety of interesting and unusual cases can be seen as at the Ellis Island Immigrant Hospital. Drawn from every race, nation and climate, one can see there all the usual varieties of disease and, in addition, peculiar tropical affections, unusual skin lesions and obscure internal disorders of the most diverse description. This hospital is excellently conducted and reflects credit on the professional skill of the officers in charge, as well as being a godsend to the immigrants who constitute its sole source of patients.

Next to Ellis Island the larger immigration points are Boston, with 45,865 entries; Philadelphia, with 45,023; Baltimore, with 22,866; and then San Francisco, Galveston, Seattle, Honolulu and Tampa. Medical examination of incoming aliens is conducted at forty-five points besides the preliminary advisory inspections made by medical officers detailed to consulates in foreign countries.

The annual report of the surgeon general for the last fiscal year contains an account of many valuable and interesting lines of investigation conducted by service officers. One of the most notable achievements was the transmission of measles from man to monkeys, the first time this has ever been accomplished. Contrary to the erroneous pop-

ular belief, measles is one of the most fatal of common diseases, largely because of complications. Ability to produce it experimentally in animals opens the way for the discovery of the causative agent, as well as of a curative or prophylactic serum.

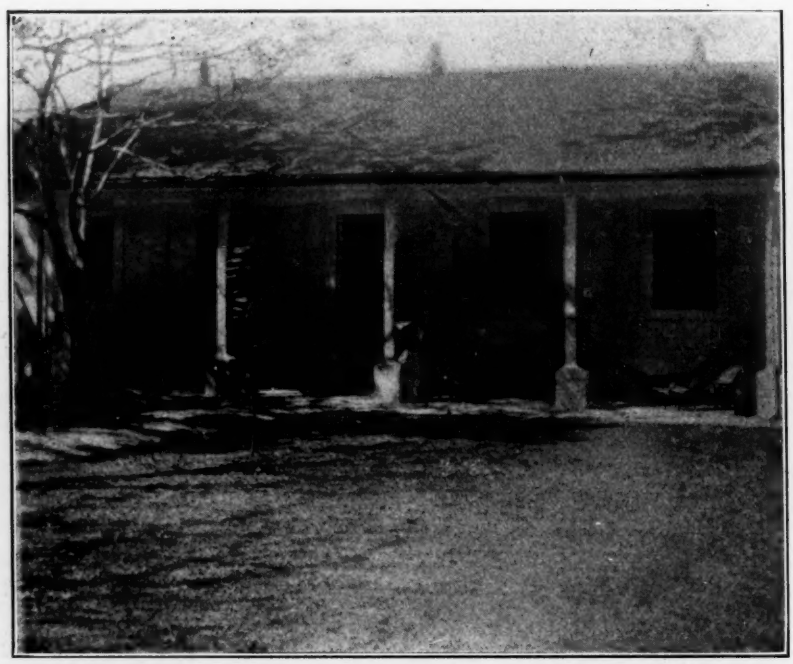
Assistance has been given to the Bureau of Chemistry of the Agricultural Department by officers of the Hygienic Laboratory in the scientific investigation of certain food products, and in giving testimony in court in trials arising under the Pure Food and Drugs Act. About one hundred proprietary medicines have been examined as to composition, strength and action.

Treatment for rabies was successfully administered to 128 persons, and 777 treatments were sent out into 14 different states. Examinations are made at the Hygienic Laboratory for tuberculosis in government employees. At the request of state authorities, officers have been detailed to determine the cause of the prevalence of typhoid fever in several states. A sanitary survey has been made of towns bordering on Lake Erie and the Niagara River and the work is being continued on all of the Great Lakes to collect data relative to their contamination with typhoid germs. The results will be applied directly to the prevention of sewage pollution, and the conservation of a pure water supply in those communities dependent for their supply on the Great Lakes.

Much work has been done on the subject of pellagra and patients

DISINFECTING WHARF AND BATHHOUSE, MARIVALES QUARANTINE STATION, PHILIPPINE ISLANDS.

with this disease have been admitted to the Marine Hospital at Savannah for special observation and study. Similarly patients have been admitted to the Wilmington, N. C., Marine Hospital for the study of hookworm infection. Two laboratory officers were detailed with the mine rescue car of the Bureau of Mines to investigate hookworm disease among miners in southern states and lung diseases among Colorado miners, and also to report on the general sanitation and hygiene of mines.



SERVICE QUARTERS, MARIVALES QUARANTINE, PHILIPPINE ISLANDS.

The San Francisco plague laboratory has continued its work of examining rodents for the germs of bubonic plague. It has also made studies on the penetrating power of various gases used in disinfecting ships, on rat leprosy and on the rôle of fleas in transmitting the plague. At the Leprosy Investigation Station in Hawaii, the bacillus of leprosy has been successfully grown on artificial media. Monkeys have been inoculated with leprosy from human beings, and thus the way has been opened for the development of a curative or preventive serum. Special studies have also been made by service officers on such subjects as the sanitary disposal of night soil; the growth of animal tissues outside the body; the rôle of oysters in the propagation of typhoid fever; the longevity of the typhoid bacillus on vegetables; and the influence of poisonous gases on health.

During the summer of 1912, plague broke out in Porto Rico and Passed Assistant R. H. Creel was detailed to direct the work of control

and eradication. In all five officers were engaged in the duty and the outbreak was limited to a small section. As at San Francisco, special emphasis was placed on rat eradication and the rat-proofing of buildings and docks. A general clean-up and enforcement of sanitary measures have been instituted. What might have been a situation full of deadly peril for this country was averted by the prompt and effective work of the service.

The report of the Secretary of the Treasury for the fiscal year of 1911 presents an optimistic picture of the operations of the Public Health Service and recommends certain features which should be further encouraged. Attention is called to the necessity of enlarging

ISOLATION HOSPITAL, CEBU QUARANTINE, PHILIPPINE ISLANDS.

the available fund for fighting epidemic disease. There should be ample provision for emergency measures which may be necessitated at any time by the sudden appearance of epidemic disease, before there is time for Congress to pass special appropriation legislation. Special appropriations are requested for the investigation of pellagra, a disease of serious menace which is spreading widely in the United States, and which threatens to become endemic at terrible cost in lives and money, as it has already done in Italy. Another building is required for the Hygienic Laboratory to provide more room for special researches, disinfection experiments and the housing of small laboratory animals.

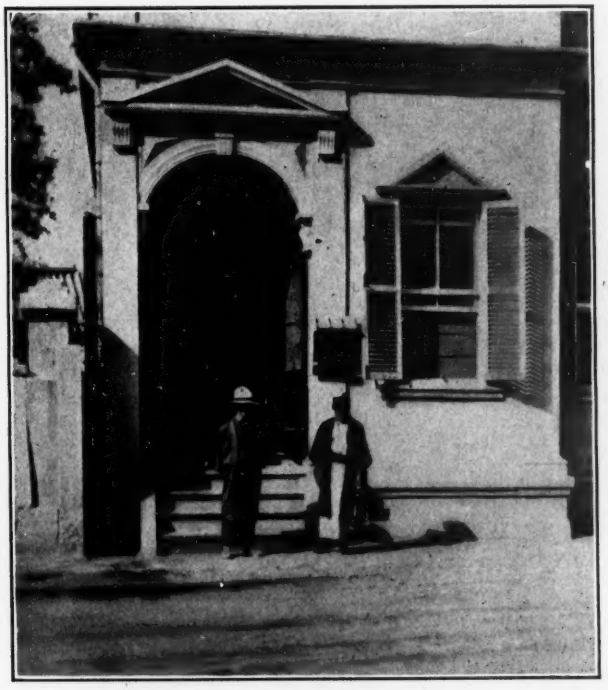
The secretary invites particular attention to the "Personnel Bill"

designed to make the pay of Public Health Service officers equal to that of the Army and Navy Medical Corps. This bill was passed by the Senate and reported favorably and unchanged to the House by the Committee on Interstate and Foreign Commerce. Every argument strongly favored its passage. As stated by Mr. Fletcher in the report of the Senate Committee on Public Health and National Quarantine, when the bill was before the Senate:

> In the opinion of the Committee, there exists no such difference in the character of the duties performed and responsibilities assumed, the hazards to which the officers are exposed, or the professional and scientific attainments required in the several services, as to warrant the existing disparity in compensation.

The committee recommended the bill to the Senate, "believing that the maintenance of the present efficiency of the Service, as well as justice to its officers, demands the equalization of pay proposed by the bill." This bill in an amended form, passed congress and was approved by the President on August 14, 1912. It provided for increased salaries, and changed the name from the Public Health and Marine Hospital Service to the more accurate and less cumbersome title, the Public Health Service. The public health functions and duties of the Service were extended. "The Public Health Service may study and investigate the diseases of man and conditions influencing the propagation and spread thereof including sanitation and sewage and the pollution either direct or indirect of the navigable streams and lakes of the United States and it may from time to time issue information in the form of publications for the use of the public."

QUARTERS OF MEDICAL OFFICER, CEBU, PHILIPPINE ISLANDS.



OFFICE OF THE PUBLIC HEALTH SERVICE, KOBE, JAPAN.

On January 13, 1912, the Senate confirmed the President's appointment of Dr. Rupert Blue to succeed the late Dr. Wyman as surgeon-general. Dr. Blue is a comparatively young man, but comes to this responsible post well prepared and with prospects bright for an administration strongly conducive toward maintaining the present high standard of the Public Health Service in personnel and efficiency, and increasing its prestige and value to the nation.

Dr. Blue was born in South Carolina in 1868, graduated from the University of Maryland in 1892, and was commissioned an assistant surgeon in the Marine Hospital Service the following year, after serving an interneship in a Marine Hospital. Four years later he passed the examination for passed assistant surgeon. He attained the rank of surgeon on May 1, 1909. His first eight years in the service were spent in the usual round of routine duties at various points in the United States. In 1903–04 Dr. Blue was detailed as executive officer under Surgeon Joseph H. White, who was in charge of the operations directed toward the eradication of bubonic plague in San Francisco. The following year he assisted in the suppression of yellow fever in New Orleans. At the Jamestown Exposition in 1907 Dr. Blue was made director of sanitation and showed ability above the ordinary in organization and in reconciling the various interests represented at the exposition and making a conspicuous success of its sanitation. He

went from Jamestown to San Francisco, where the plague had reappeared, where he handled the situation admirably, allaying friction and working in noteworthy harmony with the municipal and state officers. Later he spent some time in Europe, studying emigration, preventive medicine and quarantine management. In May, 1910, Dr. Blue was detailed to represent the service at the International Congress on Medicine and Hygiene at Buenos Ayres, and took advantage of the oppor-

SURGEON-GENERAL RUPERT BLUE.

tunities there offered to study possible routes by which yellow fever and plague might be imported into the United States.

The last detail before he became surgeon-general was in Honolulu, where he was sent to act in an advisory capacity to the Hawaiian board of health and other branches of the territory government in carrying out a sanitary program designed to decrease to the smallest possibility danger of invasion by yellow fever or bubonic plague after the opening of the Panama Canal, and to make their spread impossible, if introduced. The appointment to the surgeon-generalship made necessary the assumption of this work by Passed Assistant Surgeon McCoy, who thus takes up the rôle of adviser to the Civic Sanitation Committee of

Hawaii. This committee is particularly concerned with perfecting sanitary measures to prevent propagation of disease-bearing insects and rodents, and its work is being carried on in conjunction with the territorial board of health.

Dr. Blue has always been especially strong in the field of preventive medicine and quarantine, rather than in the line of hospital service. He is a man of engaging personality, an excellent executive, a skillful organizer and judge of men, and above all, he has in full measure the happy quality of making friends and reconciling opposing interests.

The Public Health Service stands to-day on its record and its aspirations, a monument to the men who have made it, a memorial to the gallant officers whose lives have been laid down in devotion to their duty and the principles of their corps, and the strong bulwark of the American people against the deadly foreign foes of epidemic disease, and the insidious domestic perils of poor sanitation, ignorance and prejudice.

Of more vital though prosaic importance to the nation than either army or navy, it has been less generally known and its work less completely understood. But this is rapidly being changed as the great wave of enlightenment and interest in public and national health affairs sweeps over the country, and as the knowledge is slowly increasing that prevention of disease is the primary and essential work of the physician.

THE INCREASING MORTALITY FROM DEGENERATIVE MALADIES

By E. E. RITTENHOUSE

CONSERVATION COMMISSIONER, THE EQUITABLE LIFE ASSURANCE SOCIETY OF THE UNITED STATES

IT is quite generally believed by those who have studied American morbidity and mortality tendencies that there has been a marked increase in recent years in the death rate from chronic diseases of the important and hardest worked organs of the body. They also believe that this increase is reflected in the upward trend of the general mortality rate in middle life and old age. There are those, however, who assert—obviously without investigation or analysis of the public statistics bearing upon the subject—that neither of these increases has taken place.

And there are still others, some of them prominent in the health movement, who express the opinion—also apparently without reference to the records—that the increase is natural and to be expected. Their theory is that the increase, whatever it may be, is due to the saving of lives in the younger ages, chiefly from communicable disease; that these lives passing into the older periods—many of them with weakened power of resistance—have given us more old people to die than we formerly had.

Such an increase in the number *living* in the later ages would merely lead to a correspondingly increased *number of deaths,* and not to an increase in the *death rate* at these ages, which is the ratio between the number dying and the number living.

The areas where the most dependable vital statistics are to be had, show but a trifling increase in the group above age 40 in each 1,000 of the population, while the death rate in the same group shows a very marked increase.

While the mortality experts of a number of the more important life insurance companies have recognized the increasing mortality in the older ages, and in some instances increased the severity of medical examinations, and in others increased premiums at those ages, only one of the larger companies and one of the smaller ones have given especial attention to the excessive life waste in these ages in their health conservation work.

Mortality Statistics

Much progress has been made in recent years in popularizing our vital statistics, but still much valuable information which should be

placed before the public in concise and popular form lies buried in our official records and in the files of our statisticians and scientists who have analyzed them for their own or scientific use.

Owing to the incompleteness of mortality statistics, especially in former years, it is frequently necessary in making comparisons to insert personal estimates to fill gaps. The rates in such instances are, therefore, deduced partly from statistics and partly from personal judgment.

The statistics used in arriving at the comparisons given below were, however, sufficiently complete to render unnecessary the interpolation of estimates to fill omissions, with one unimportant exception.[1] The rates deduced are the direct product of existing official reports, which are accessible to any one desiring to look them up.

The purpose of submitting these ratios is not primarily to fix a specific rate of increase, but to indicate the *trend* of mortality in middle life and old age in the area named. Those interested in the subject will judge the measure of the actual increase by the value they may place upon the original data from which these rates are extracted.

Degenerative Diseases

That the ratio of deaths from the more important degenerative affections has increased sharply in recent years is so generally known that it is needless to present in this brief paper the indicated advance

Degenerative Diseases

Massachusetts 1880–1909.[2] *Increase in the Death Rate (per 10,000 Population) by Age Periods*

Ages	1880	1909	Increase	Per Cent of Same
All	23.21	43.26	20.05	86.38
Under 5	7.92	10.36	2.44	30.8
5– 9	2.91	3.95	1.04	35.7
10–14	2.85	4.72	1.87	65.6
15–19	3.10	5.43	2.33	75.2
20–29	4.95	8.09	3.14	63.4
30–39	10.13	18.79	8.66	85.5
40–49	19.70	37.84	18.14	92.1
50–59	39.01	91.30	52.29	134
60–69	102.05	212.93	110.88	108.7
70 and over	261.1	558.2	297.1	113

in the rate for each disease separately. They are, therefore, grouped by age divisions. By this method the disturbing effect on the rates of

[1] In the absence of the official figures of the age divisions of the population for 1910, the *ratios* of distribution of 1900 were used. Inasmuch as the change in the percentage of living at the different age periods is very slight in one decade, the actual ratios for 1910 will make no appreciable change in the mortality rates here given.

[2] Massachusetts State Registration Reports.

any changes in classification or improvement in diagnosis is largely overcome. The most reliable records available for this purpose, giving age divisions in 1880, are those of Massachusetts. While the death rates in childhood and early adult life are relatively small, they too show a significant increase.

Included in this group are apoplexy, paralysis and diseases of the heart, circulatory system, kidneys and liver.[2]

The most important of the other diseases of middle life and old age that has increased is cancer. Comparing 1910 with 1880, the cancer death rate has increased in Massachusetts 66 per cent.; since 1900 it has increased 31 per cent. External cancer alone has increased in the entire registration area 55 per cent. since 1900.[4]

In 16 cities the mortality rate from organic heart, apoplexy and kidney affections alone has increased in 30 years from 17.94 to 34.78, or 94 per cent.; during 10 years (1900–1910) it increased from 29.4 to 34.78, or 18 per cent. In New Jersey, 1880–1910, it increased from 16.5 to 34.3, or 108 per cent.

The curves vary in different states and cities, but the same general trend is observed wherever statistics relating to these causes of death are available.

General Death Rate—Older Age Groups

In 1880 the comparisons are confined to Massachusetts and New Jersey, and to 16 registration cities, because in these areas we have the most reliable statistics[5] of that time, from which these comparisons can be carried through to 1910. Both of these were normal mortality years,[6] and, it is believed, represent a fair average of the preceding five-year periods.

That this upward tendency has continued is indicated by a comparison of ten registration states[8] 1900–1910. Increases: ages 45–49,

[2] The estimated deaths in 1910 from these diseases in the United States (based upon the Reg. area) were 367,700.

[4] U. S. Mortality Statistics, 1900, Census Bulletin 109, 1910.

[5] "The state and municipal registration records were copied and are used in the tabulations instead of the enumerators' schedules. These state and municipal registration records are based on a system of burial permits, and are therefore, probably very nearly accurate. This fact should be borne in mind in comparing the reported mortality of these with that of other localities." (U. S. Census Report, 1880.)

[6] "The census year 1879–80 was probably a fair average year as regards mortality. No great epidemic occurred during this period, unless we may consider a marked prevalence of diphtheria as such." (U. S. Census Report, 1880.)

[8] Registration states in 1900 were: Massachusetts, New Jersey, Connecticut, Maine, Michigan, New York, New Hampshire, Rhode Island, Vermont, District of Columbia and Indiana. Indiana is omitted in comparisons owing to lack of uniformity in age distribution records.

SIXTEEN[1] REGISTRATION CITIES. 1880–1910

Decrease and Increase in General Death Rate (per 1,000 Population) by Age Periods

Ages	D.R. 1880	D.R. 1910	Dec. and Inc. in Rate	Per Cent. of Same
All	22.09	16.36	— 5.73	—26
Under 35	21.4	11.36	—10.04	—47
35–44	13.6	12.29	— 1.31	— 9.6
45–54	18.3	22.07	+ 3.77	+20.6
55–64	29.3	37.54	+ 8.24	+28.1
65 and over and unknown	80.3	89.30	+ 9	+11.2
Above 45	32	40.10	+ 8.10	+25.31
Above 55	48.44	58.82	+10.38	+21.43

.61, or 4.5 per cent.; ages 50–54, 1.16, or 6.7 per cent.; ages 55–59 (decrease), .13, or .5 per cent.; ages 60–64 (increase), 1.48, or 4.6 per cent.; ages 65–69, 3.23, or 6.75 per cent.; ages 70–74, 3.45, or 4.9 per cent.; age 75 and over, .82, or .6 per cent.

MASSACHUSETTS AND NEW JERSEY. 1880–1910

Decrease and Increase in General Death Rate (per 1,000 Population) by Age Periods

Ages	D.R. 1880	D.R. 1910	Dec. and Inc. in Rate	Per Cent. of Same
All	17.63	15.80	— 1.83	—10.38
Under 30	16.3	11.3	— 5.0	—30.6
30–34	9.12	6.99	— 2.13	—23.3
35–39	10.1	8.90	— 1.20	—11.8
40–44	10.20	10.95	+ .75	+ 7.35
45–49	12.20	13.79	+ 1.59	+13.0
50–54	13.70	18.35	+ 4.65	+33.9
55–59	20.49	24.28	+ 3.79	+18.5
60–64	25.69	34.85	+ 9.16	+35.6
65–69	40.5	53.16	+12.66	+31.2
70–74	55.4	75.96	+20.56	+37.1
75 and over	123.68	143.66	+19.98	+16.1
Above 40	25.10	30.42	+ 5.32	+21.20
Above 50	35.24	44.07	+ 8.83	+25.06
Above 60	53.81	67.73	+13.92	+25.87

To summarize, the public records under consideration indicate that:

1. The mortality rate from apoplexy, paralysis, diseases of the heart, circulatory system, kidneys and liver has heavily increased in the younger as well as in the older groups. The total deaths were 367,700 in 1910.

2. In Massachusetts the death rate from these causes has increased 86.4 per cent. in 30 years.

3. In 16 important cities the death rate from organic diseases of the

[1] Sixteen cities: New York, Chicago, Philadelphia, Brooklyn, St. Louis, Baltimore, San Francisco, Cincinnati, Cleveland, New Orleans, Pittsburgh, Washington, Milwaukee, Louisville, Providence, Indianapolis.

heart, and from apoplexy, Bright's and nephritis has alone increased 94 per cent. in 30 years.

4. In Massachusetts the death rate from cancer has increased 66 per cent. in 30 years, and 31 per cent. during the past 10 years.

5. In the entire registration area the death rate from external cancer alone has increased 55 per cent. in 10 years, from 1900 to 1910.

6. The increase in mortality from diseases of middle life and old age is reflected in the general death rate by an increase commencing in Massachusetts and New Jersey in age group 40–44; in 16 cities group 45–54.

7. The death rate of the total population age 40 and over has increased, 1910 over 1880:

In Massachusetts and New Jersey, 30 years	5.3, or 21.2 per cent.
In sixteen cities, 30 years	8.1, or 25.3 per cent.
In ten states, 10 years (1900–10)	.89, or 3 per cent.

The increase in the proportion of older lives in our population has been very slight and could not account for the increase in the death rate.

To what extent are these adverse mortality tendencies reflected in our *total* population? In estimating the probable increase in the entire country, many factors must be considered, the discussion of which would consume many pages.

The rate of increase in Massachusetts and New Jersey (21 per cent.) doubtless approximates that of all of the populous states of the east. This rate would, however, be reduced if merged with the rate of increase for the agricultural population of the western and northwestern states. On the other hand, this reduction would be largely, if not totally, neutralized by the heavy urban and rural mortality in the south.

It would seem an entirely reasonable conclusion that while the average length of life has advanced, the *extreme span* of life has not done so—in fact, the indications are that it has been shortened.

Our failure to adapt ourselves to the extraordinary changes and strains of modern existence is commonly accepted as the cause for this excessive mortality in the later age periods. Even though the statistics indicated no increase, the urgent need for correcting our living habits would still exist.

We may agree that in the long run the trend of humanity is ever upward, and that this is but a temporary reaction, but can we afford to rest wholly upon the hope that race deterioration will automatically cease when our people have had time to adjust themselves to modern conditions? Wise men doubt it. This problem will not solve itself; this adverse tendency will be checked only when our people are made to see conditions as they actually exist, and are aroused to the need of correcting them.

THE LIFE INSURANCE COMPANY AS A DYNAMIC IN THE MOVEMENT FOR PHYSICAL WELFARE

By EUGENE LYMAN FISK, M.D.

MEDICAL DIRECTOR, POSTAL LIFE INSURANCE COMPANY, NEW YORK

THE average careless liver, although he may be perfectly willing to swallow some "magic" elixir, exhibits uneasiness tinged with suspicion when approached on the subject of prolonging his life by means of adjusting him to his environment. He is more than likely to regard the span of life as fixed by some immutable, if not divine, law, and while comfortably optimistic about attaining the limit fixed by such law, cherishes but little hope of "beating the game." In other words, that convenient individual, the "man on the street," is sceptical about materially prolonging his life without surrendering some of the indulgences which he thinks make life worth living. It is this attitude of mind which leads him frequently to characterize the health-reformer as a "kill-joy," who is "against everything." Now it is unquestionably true that the health-conservation activities that have lately arisen in a few of the leading life-insurance companies have for their business object a mere mathematical increment to the years of life. Indeed, the only legal warrant for the expenditure of the policyholders' money in this work is the probability of attaining such a result, and thereby lowering the cost of insurance. But it is far from the minds of those directing this new force for human betterment, to advocate a mere niggardly or parsimonious hoarding of existence, without regard to its quality, color or meaning. The real warfare is against needless misery, preventable disease, mental and physical inefficiency, and the pitiable handicaps that not only shorten life, but take out of it the color and the satisfaction that make it worth living. Using the term in no sinister Nietzschean sense, the superman should not only live long, but live well, deriving his joy in life from the normal hormones circulating in his tissues, and not from the fleshpots or narcotic indulgences of our friend the careless liver. The prolongation of life is the end that justifies the financial expenditure, but the immediate work in hand is to make life more livable.

Let it be understood, then, that the health-conservationist who is not himself in need of mental hygiene is "against" many things, in favor of many things, and out to kill only the kind of "joy" that kills.

The belief that the death-rate, especially among selected insured lives, is a fixed quantity, is still held by many experienced insurance

men, notwithstanding much recent evidence to the contrary. The constant use of actuarial tables, both in business practise and in the statutes governing the maintenance of reserves by life-insurance companies, tends to give a certain fixity and authority to such tables which they derive from no natural law.

The recent medico-actuarial investigation of the experience of 43 American companies, for example, shows a marked improvement since the quinquennium 1885–1890, among the younger-age groups, and a distinct deterioration among those over age 60.

Any assumption that either the death-rate or the span of life is a fixed quantity necessarily involves the postulate that either the conditions affecting the mortality are unchanging, or that each change is neutralized and balanced by some other change, thus keeping the rate in equilibrium.

As a matter of fact, the general death-rate throughout the civilized world has been falling for several centuries, although there is no evidence that the span of life has increased within recent years, the lowered death-rate resulting largely from the saving of lives in the younger age-groups.

That these movements of mortality are not beyond the control of man is shown by this lowering of the death-rate in the age-groups most affected by the communicable diseases which have recently yielded to the attacks of science. That science can likewise influence the mortality from diseases resulting from faulty living-habits or the mere wear and tear of existence, can not be questioned, and the alleged mysterious fixity of the death-rate or of the span of life should not be held up as a bugaboo to restrain such efforts.

That the mortality in the average life-insurance company is far higher than it need be, and could be lowered, even among good, average insured lives, by improved living-habits, is shown by the experience of the United Kingdom Temperance and General Provident Institution.

This remarkable exhibit shows that in the institution mentioned, two large bodies of lives, almost equal in numbers, and homogeneous except for the use of alcohol, moved alongside of each other for forty-four years, and that one group, the abstainers, at all times exhibited a markedly superior vitality to the other group—the non-abstainers—the total difference in favor of the abstainers during the period covered being 27.4 per cent., although the mortality among the general, or non-abstaining class was only 91 per cent. of that expected according to the British O^m Table, representing the experience in 63 British offices. This is not an isolated experience, as recent British and American experiences show an even greater difference in favor of the abstainer.

Now it is fair to assume that if, by educational methods, a company could influence 10 per cent. of its policyholders to lead a careful hy-

gienic existence, the mortality in such a group would be lowered at least to the degree exhibited by the abstainers in the British company above referred to.

Inasmuch as the net premium for an abstainer at age 35, under an average distribution of endowment and whole-life policies, would be $3.03 per thousand of insurance in force less than for a non-abstainer, we have here a figure representing the actual saving on such lives, the net premium being comparable to the cost of manufacture in trade. Applying this factor to the old-line insurance in force in the United States—about $18,000,000,000—a saving would result, over and above the cost of carrying on the work, of $5,000,000 annually. There would also be an annual saving of approximately 10,000 lives. These are the mini-

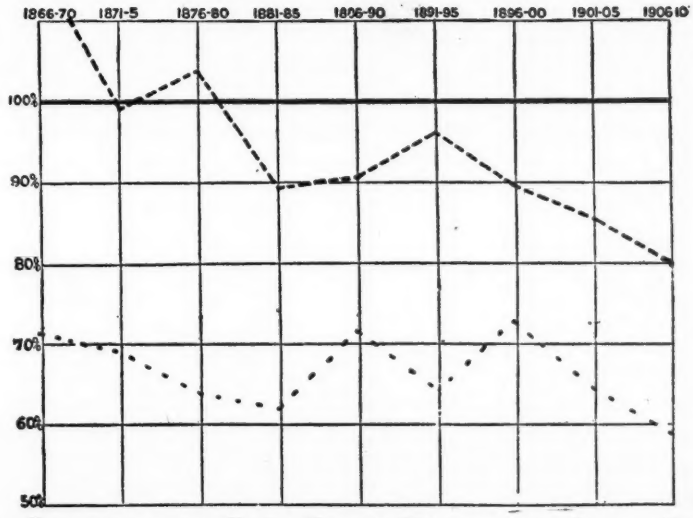


FIG. 1. EXPERIENCE OF THE UNITED KINGDOM TEMPERANCE AND GENERAL PROVIDENT INSTITUTION OF LONDON. Healthy males; whole-life policies; amounts; 1866–1910.

Expected mortality, British O^m table ..... ———————— 100.00%
Ratio actual to expected mortality, non-abstainers ..... — — — — — — 91.27%
Ratio actual to expected mortality, abstainers 66.25%

Mortality among abstainers 27.4 per cent. less than among non-abstainers.

mum figures that can be derived from any scientific ground of experience. They can be increased according to one's confidence in the ability of hygienists to guide the public into conservation methods of living. No effort is here made to compute the enormous reflex benefits to the public at large from these activities among insured lives.

Is the work worth while? If so, how can it be carried on to the best advantage? The answer is found in a brief survey of the resources of the life-insurance companies. 25,000,000 old-line policyholders pay annually, to about 250 companies, more than $600,000,000 in premiums; these companies hold $4,000,000,000 in assets to protect $18,000,0000,000 of insurance in force; they employ 20,000 agents and 80,000 medical examiners, in addition to home-office employees, banks

of deposit and collection, etc., and they pay out more than $400,000,000 annually in death-claims, endowments, etc., to policyholders, all of which is evidence of the vast and intricate ramifications of the business throughout the social structure. Every policyholder is in touch with at least two other individuals, thereby affording the life-insurance companies seventy-five million points of contact with the public, and constantly open channels of communication through which educational material may be transmitted.

We may summarize the reasons why life-insurance companies should engage in health conservation work as follows:

1. The machinery is at hand.

2. It can be utilized without loss, and with probable gain to both company and policyholder.

3. The very nature and extent of the life-insurance business imposes a public obligation to exercise this power for the welfare of the people.

The medical and scientific staff of a life-insurance company is trained in the consideration of disease-tendencies, rather than active diseased conditions. The influence of living-habits and the significance of physical disabilities and abnormalities, and especially of personal and family history, upon large masses of insured lives, form the body of the rapidly developing science of medical selection. By combining this intrinsic knowledge with the readily available extrinsic data relating to personal hygiene, the medical officers of a life-insurance company are, or should be, especially well equipped to guide their policyholders toward safe and sane living-habits. Furthermore, experience shows that the policyholder will listen to the advice of his life-insurance office on such matters, because he discerns the practical business motive that prompts it, however liberal an admixture there may be of normal, genuine interest in human betterment.

The lines along which such work may be carried on are too numerous to permit of minute description in this article. Briefly, they may be summarized as follows: health-hints and instructions distributed with premium-notices; periodical bulletins covering the fundamental principles of healthful living; cooperation with boards of health and other welfare-agencies, by furnishing statistical and other information accumulated by the company's bureau of research; the creation of public sentiment where needed, for the enforcement of health-laws and proper equipment and support of health-departments; persistent effort in favor of legislation for the proper registration of vital statistics; persistent publicity to the need for national, state and local warfare against preventable disease, not only of the communicable class, but of those conditions arising from wear and tear, maladjustment and faulty living-habits. These are a few of the many activities that could readily be carried on by well-equipped life-insurance companies.

The best way to learn this game is to play it. There is such a wealth of opportunity that after the work is once commenced, organization and development will soon follow.

Probably the most important and direct way to benefit the policyholder, and—by force of example—the public at large, is through a system of free, annual, medical examinations, for the purpose of detecting disease or disease-tendencies at the earliest possible moment. This principle of periodic inspection or examination, which seems so radical as applied to man, is accepted as commonplace when applied to the institutions or machines employed by him, such as banks, insurance companies, steam-boilers, elevators, life-preservers, etc., none of which can compare with the human organism in value, complexity or capacity for going wrong. Why not examine the human machine every year? Is there any important objection, except man's silly, subconscious feeling that he is a thing apart from the rest of nature. The *bacillus typhosus* has no such illusions regarding man's apartness, and, however difficult it may be to apply the law of the conservation of energy to man's mental processes, there is no doubt but that it applies to his body, and that the violation of physical and physiological laws is followed by damage and degeneration which are not always manifest until they are beyond the power of science to repair. Many a life has been saved by the warning of incipient disease gained through a life-insurance examination. Why should such benefits be casual instead of systematic?

So much for theory. In a modest way, the company with which I have the honor to be associated has for several years been trying out these theories in the laboratory of practical business experience. Our Health Bureau was established in 1909, and has covered the following activities: periodical bulletins have been issued, dealing with such subjects as the causation of degenerative affections of the heart, blood vessels and kidneys; affections of the nose, throat and lungs, with preventive measures; hygiene of the eye; dental and oral hygiene; obesity and its prevention; drug addiction; physiological effects of alcohol and tobacco; causation and prevention of typhoid, yellow fever, malaria, pneumonia, etc.; increase in the death-rate from cancer, and how to meet it by general and surgical methods; courage as a health-asset; diet-hints; summer and winter hygiene, etc. Statistical pamphlets, addresses, etc., have been issued, showing the increase and decrease in mortality from various diseases, and practical lessons have been drawn therefrom. Many thousands of such monographs have been distributed to boards of health, schools, colleges and other centers of social influence. The privilege of free annual medical examination has been extended to policyholders since 1909. Although less than 10 per cent. of the policyholders have annually availed themselves of this privilege, the results more than justify the company's action. Forty per cent. of the risks examined were found impaired, as some misinterpreted the system as an emerg-

ency relief plan for the sick, rather than a measure of disease prevention. Nevertheless, of those found impaired, 44 per cent. were absolutely unaware of their impairment, showing the positive need for such a system. The following analysis of the impaired lives may prove of interest:

ANALYSIS OF RISKS FOUND IMPAIRED
FREE ANNUAL HEALTH BUREAU EXAMINATIONS

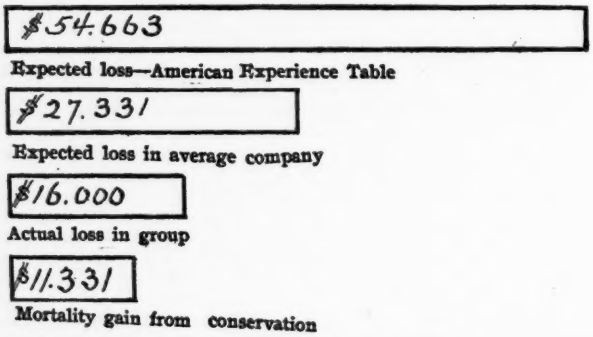
Average age, 49 years, 9 months. Amount of insurance, $1,590,635.

Diseases	Ages 29–30, Per Cent.	Ages 30–40, Per Cent.	Ages 40–50, Per Cent.	Ages 50–60, Per Cent.	Ages 60–70, Per Cent.	Ages 70 Over, Per Cent.	Per Cent. Total Number Examined
Affections of heart, blood vessels and kidneys, diabetes	4.98	13.85	21.65	31.60	23.37	4.54	28
Per cent. at each age-period unaware of such impairment	65.21	57.81	63.00	60.27	56.48	57.14	.....
Pulmonary	4.76	35.71	33.33	14.29	11.90	.....	2.5
Nervous	6.82	22.72	38.63	22.72	9.09	.....	2.7
Digestive	1.66	33.33	25.00	31.66	8.33	.....	3.6
Miscellaneous	2.22	17.77	42.22	22.22	13.33	2.22	2.7
Distribution of all impairments by age-periods	4.59	17.91	25.11	29.09	19.60	3.37	39.5

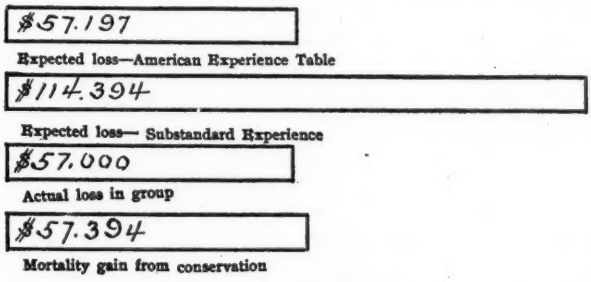
The above should be interpreted as follows: Of the risks showing affections of heart, blood-vessels, kidneys and diabetes, 4.9 per cent. were between 20 and 30, 13.8 per cent. between 30 and 40, etc. 63 per cent. of those between 40 and 50 affected with diseases of heart, blood-vessels, kidneys and with diabetes were unaware of impairment. 4.5 per cent. of all impairments found occurred in the age-group between 20 and 30, 17.9 per cent. between 30 and 40, etc. 96 per cent. of those unaware of impairment exhibited affections of heart, blood-vessels, kidneys and diabetes. 39.5 per cent. of those examined were found impaired.

Attention is called to the large percentage of degenerative affections found at middle life, among those who supposed that they were in sound health.

The mortality experience, although derived from a comparatively small group, has extended over a sufficient period to prove instructive, and is set forth in the following charts:



GROUP I. No impairment found



GROUP II. Impaired

FIG. 2. ANALYSIS OF POLICYHOLDERS WHO AVAILED THEMSELVES OF THE PRIVILEGE OF FREE ANNUAL MEDICAL EXAMINATION, 1909–1912.

Among those found unimpaired, the mortality was only 29 per cent. of the American Experience Table, showing a saving of about 21 points of the mortality expected by the average company among lives exposed for like periods. These risks, although unimpaired, were advised regarding living-habits, eating, drinking, smoking, etc., and the saving indicated is properly credited to this system.

The group reported impaired comprised some individuals who were almost *in articulo mortis,* hence an expected mortality of 200 per cent. of the American Experience Table might have been regarded as well within the mark. However, the actual mortality in the group was only 99 per cent. of that table. That is, where we expected 200 to die, only 99 deaths actually occurred.

The net saving, over and above the cost of operation of our bureau, was at the rate of about $20,000 per year. Now, the annual saving, based upon the hypothesis derived from the British company's experience would, in our company, have been at the rate of about $12,000 per year, showing that the theoretical estimates were conservative, and more than justified by the actual test of experience. The full effect of the educational propaganda could not, of course, be traced in the mortality fluctuations even of a very large company, and I have only attempted to show the results among those who were actually known to be in touch with our health bureau.

Important health-conservation activities are as yet carried on by only three leading companies out of the 250 now operating in this country. The health bureau established in the Association of Life Insurance Presidents, in 1910, is keeping alive the conservation-idea, but it is a mere adumbration of what could and should be accomplished through the enormous resources available. The pressure of public opinion is needed to set in motion this vast machinery for lifting the burdens of humanity.

NATURAL SELECTION

By Professor T. D. A. COCKERELL
UNIVERSITY OF COLORADO

THE lowest forms of life show the greatest stability in their specific characters. Any one who will examine a little pond water under the microscope will see numerous minute Protozoa belonging to different families, genera and species. Close study brings out the fact that although we regard these as very low types, they are complicated little animals, with remarkable characters. When we look at lists of these creatures, based on collections from different parts of the world, we are astonished to find that most of the species are the same, no matter how remote the localities. When identifications were based merely on comparisons of descriptions and figures, we suspected that the alleged wide distribution of some of these fresh-water Protozoa might be due to mistakes. In recent years, however, protozoologists have frequently traveled, and Dr. Penard, the greatest authority on rhizopods, has been able to determine by study on the spot the identity of Rocky Mountain forms with those of Switzerland. Even more remarkable are the results of Dr. Edmondson, who has visited Tahiti, high altitudes in the Rocky Mountains, and various places in the western central states, with the result of entirely confirming the opinion that most species of fresh-water Protozoa are spread over the world, almost without regard to climate or altitude.[1]

These studies and reports, however, have been based on the species as generally understood. These species are not entirely uniform, but consist of groups of minor races, which also appear to have constant characters and to be of general distribution. Dr. Penard told me that he could greatly increase the list of "species" of rhizopods were he to describe as distinct all the apparently constant forms which he had learned to recognize, and which, so far as he knew, did not conjugate one with the other. He did not describe and name them because their separation required such critical comparisons and familiarity with the subject that very few naturalists would be willing to consider them. Professor Jennings, in his studies of *Paramœcium,* has isolated a number of races or varieties which possess constant characters by which they can be recognized, and which are believed to be common throughout the country.

[1] *University of Colorado Studies,* IX., pp. 65–74; *Science,* September 9, 1910.

Are these Protozoa, then, indifferent to their surroundings? By no means. The experiments of Jennings show that uniformity of environment is not possible even in a watch glass, and that the animals respond readily in many ways to the conditions under which they exist. This fact has tended to obscure the genetic independence of different races, the characters of which overlap, but "pure line" cultures have made it possible to separate them. It has been shown that distinct races may differ only in average characters, a large proportion of the individuals, under ordinary conditions, being indistinguishable by inspection. Such a pair of races would only show absolute differences if subjected to conditions ensuring for every individual the maximum or the minimum growth and efficiency. Such conditions are practically unattainable, and only "pure line" breeding and statistical study will separate the races.

Consequently, in the Protozoa, we have three recognized grades:

1. The species of ordinary taxonomic writings.

2. The minor types recognizable by inspection when the investigator is very expert.

3. The races or strains separable only by breeding combined with statistical study.

Do the third originate frequently without evident cause? Do they then turn into the second, and the second into the first? Jennings did not find it so, but his experiments necessarily occupied a limited time and were concerned with an infinitesimal fraction of the unthinkable myriads of *Paramœcia* in the world. We have, however, the results of nature's large-scale experiment with *Paramœcium*. The genus, notwithstanding its universal distribution and the very diverse conditions under which it must exist, is very poor in species. Either the imagined process does not go on, or it fails before reaching the stage of species-formation, as species are understood by the taxonomists.

In the case of bacteria, and even trypanosomes, it is commonly alleged that environment will change the type. This is constantly asserted by the highest medical authorities, and in a certain pragmatic sense it is of course true. It is found, however, that if the environmental factor is carried too far, or continued too long, the process can not be reversed. It seems nearly certain that the observed phenomena are due to nothing more than a selective process operating on a mixture of races, isolating the one least able to endure. Thus, suppose in a given case we have a culture consisting of one million pathogenic bacteria and ten of an allied non-pathogenic race (presumably there will usually be several grades or races, as with the *Paramœcia*). Apply some treatment favorable to the ten and destructive to the million, and presently the ten are a million and the million reduced to ten or none. The

appearance is that of changing the type by environmental means, but nothing more than selection has been at work.[2]

From all this we are led to conclude that natural selection is continually operative on the lower types of life, the unicellular animals and plants, everywhere affecting the proportions or existence of the races and species. These creatures are *not* adapted to life under all conditions; they are, on the contrary, sensitive to relatively slight changes, many of them probably too slight for us to appreciate. The history of a single culture in the laboratory indicates this. Why, then, are the species so widely distributed, and, on the whole, so constant? Why are they not infinite in number? Why are they not exterminated in great numbers, instead of being of tremendous antiquity, as their wide distribution and the paleontological records show? Where the environment is highly specialized, as in the case of groups parasitic on the higher vertebrata, there is considerable evidence that evolution has to a certain extent kept pace with that of the hosts; yet always tending to lag behind, as Kellogg showed even in the case of the bird-lice, which are of far higher organization than the types now under discussion. In the case of such animals as the fresh-water Protozoa, however, the selective processes have always acted piecemeal, rarely if ever sufficiently widely to destroy a species which had once gained a good footing. They have no doubt destroyed many incipient species, but any tolerably successful type, once widespread, may defy the ordinary processes of nature. In a wide country there is nothing which renders *every* puddle uninhabitable, or *every* part of each pond and river, and survival in a number of places permits the reappearance of the creature in millions when good conditions for reproduction occur. All that is necessary for permanence is an inherent stability of type, which will prevent automatic modification independent of conditions. This stability surely exists in an amazing degree, and may itself be regarded as a product of selection acting through the ages; for automatic instability, manifested too much or too often, would lead to series of changes eventually fatal to existence. A certain looseness of adjustment to surroundings is advantageous, but even slight variations, piled one upon the other, would before long throw the organism out of gear.

Perhaps we may picture the condition of affairs somewhat as follows: There are, let us say, 500 common "situations" in the fresh waters of the world, differing in the temperature and chemical content of the water, in the presence or absence of particular enemies, in the quantity and quality of available food, and I know not what else. These are

[2] There is some evidence, the precise value of which can not at present be determined, pointing to a selective destruction of certain germinal elements under special conditions. This, if adequately confirmed, may equally explain some of the results obtained with trypanosomes, and the often-quoted work of Tower and MacDougal in inducing heritable variations.

not constant for any one body of water for any length of time, owing to seasonal and other changes. An organism adapted equally to any one of the 500, if that were physically possible, could not be *closely* adapted to any, and would be perhaps more or less inefficient under all. An organism adapted exclusively to one or two of the 500 could not in practise confine itself to them, and would be in danger of extermination. There would accordingly arise an optimum condition of adaptability, according to which any given organism would exist under at least 300 of the 500 postulated conditions, would do well under 100, and would flourish exceeedingly well under perhaps 10. Hence the species would be very widespread, would often be common, and would occasionally occur in excessive numbers; which is approximately what we find.

All of this would require in the animals much stability of type. If they varied freely and indiscriminately, the variations being inherited, they would not only tend to lose their standards of efficiency, but the selective processes might make playthings of them, changing them temporarily to meet this or that condition, but rarely able to reverse quickly enough as conditions altered.

The rhizopodous genus *Difflugia* contains a great number of species, differing in the size and shape of the little shells they make. It is not necessary to suppose that *each* species is *specially* adapted to some particular set of conditions, though some of them may be more or less so. It is only necessary to suppose that the difflugian type reached in these animals so many "positions of organic stability," which persisted and survived simply for this reason. There is a "survival of the fittest" in inorganic chemical compounds, following analogous lines.

There is the greatest contrast between these fresh-water protozoans and some of the marine groups, particularly the Radiolaria. Haeckel's great *Challenger* report on the radiolarians only partially indicates the enormous diversity of skeletal structure in these animals. They remind us more of snow crystals than anything else and it is useful to remember here that snow crystals, with all their wonderful diversity, are simply H_2O. It is impossible to believe that all this radiolarian diversity can be adaptive in more than the most general way; we would rather believe that it is possible because of the relative simplicity and uniformity of the conditions of life, which permit infinite diversity in the details of skeletal structure without injury. There is perhaps a high degree of stability in the protoplasmic structure of the radiolaria, and the modifications in the skeletons or shells may not indicate much fundamental diversity. To what extent the described species are permanent and constant is not known.

In multicellular animals, conditions are in many ways different; yet even here we notice a remarkable limitation in the *types* of cellular

structure produced. What multitudes of animals are made out of essentially the same *kinds* of tissues! How limited in number those kinds are! The plants show the same lack of cellular diversity. Evolution has proceeded by means of new arrangements rather than new materials. This cellular stability, well fitting the needs of organisms, must have been fostered by selection. The nerve cell, the striated muscle cell, are astonishingly modified from ameboid ancestors, but the power that could do so much has left us only a few masterpieces. Is this the result of orthogenesis? Did development proceed along these lines, looking neither to the right nor to the left; or did selection oppose impassable barriers? Perhaps both, since orthogenetic trends may themselves be favored by selection.

Passing from tissues to organs and characters, we seem to find much greater, almost infinite, diversity. Recent research has, however, indicated the presence of determiners in the germ-plasm, factors which may be combined in endless ways in inheritance, but are themselves remarkably stable. It seems nearly certain that, so far from constantly presenting heritable variations, they rarely do so. This conclusion is based not merely on the Mendelian phenomena observed by experimenters, but also on the paleontological evidence. There are many groups of species, such as the oysters and the oaks, which have existed since Mesozoic times, producing innumerable species, but so far as we can see, practically all by the shuffling of characters present within the genus all along. Among the Unionidæ, the fresh-water mussels, Ortmann has recently commented on the occurrence of practically identical shell characters in different genera; while land snails afford a number of similar instances. In insects, these phenomena are constantly observed; types of color and marking are nearly the same in Lepidoptera of diverse structure; and in some of the Hymenoptera peculiar characters, such as spines on the cheeks, appear here and there as if at random. In one genus of bees the sexes differ in the character of the tongue, one having that organ pointed, the other having it obtuse; differences hitherto considered to mark families.

We are, therefore, led to see a certain stability amidst all the instability of the multicellular animals; a stability of types of tissue on the one hand, a stability of determiners on the other. Change in the stuff of which living things are made is not a common phenomenon; indeed, we know little or nothing about it. The experiments of Tower and MacDougal, in which heritable variations were apparently produced, can be explained rather on the supposition that certain determiners were destroyed than on the idea that they were altered.

Natural selection, it has often been said, creates nothing. It merely makes use of the variations already present. In Darwin's time, it was not appreciated that so many of the observable variations are due to the

direct effects of the environment, and are not inherited. To-day, we must throw these out and consider heritable variations only. Now we find that these heritable variations mainly (at least) represent no more than a shuffling of the stock-in-trade of the organism, and if any of them involve absolutely new determiners, we do not know it. The matter is complicated by the frequent appearance of new *characters*, which experimental evidence shows to result from new combinations of the old ones. Thus the pink-flowered and yellow-flowered stocks (*Matthiola*) give white and red-cream flowers in the third (second filial) generation, no matter if the two original strains had been bred true and had remained constant from the beginning of time. Here we seem to see something entirely new, but analysis shows that we have no more than new combinations of certain of the grandparental characters.

What will natural selection do with such materials? It can do no more than favor certain characters or combinations of characters and eliminate others. It can not even eliminate the recessives. The result will be the production of a number of distinct types, without necessarily any forward evolution—anything more than a shuffling and sorting of determiners. So far as we can see, this is exactly what has happened in the case of the oak leaves and many mollusc shells.

The modern school of Mendelian experimenters, who have from necessity confined themselves to determining the inheritance of relatively simple characters, have come to think little of natural selection. They have seen how various combinations can arise, greatly altering the appearance of animals and plants, without selection having anything to do in the matter. They have also seen how certain of these modified types, or others like them, may multiply and spread, without being obviously helped or hindered by selective agencies. Where the characters came from, they do not know; but neither do the selectionists. Let it suffice that we have here an apparently mechanical arrangement, which if left to itself will people the earth with diverse animals and plants, a large proportion of which will get along well enough to survive. Possibly this description is unjust in its application to modern experimenters generally, but it at least represents the attitude of some of the more influential and at the same time marks the recognition of a number of real and important facts. I think that while we shall gladly incorporate the facts into our system, we shall in time come to wonder at the limited view of nature implied by the attitude described. It is all too simple and too easy, it does not take into account the real complexities of life or of organization. It reminds us a little of the school of zoogeographers who would bridge the oceans whenever it seems necessary for some animal to cross, or to have crossed. The experimental work itself is revealing this, as day by day new complications arise.

Darwin and Wallace have talked of the accumulation of small variations, of the effects of natural selection on the perpetual minute variations which all species exhibit. Antiselectionists answer that most of these are non-heritable "fluctuating variations," and as for the rest, they are usually not small, nor is the variation "continuous." Moreover, selection soon gets to the end of its rope. So it seems when we are looking at a single pair, or two or three pairs of Mendelian allelomorphs, all active independently of one another. This, however, is not a true picture of living animals, which are bundles of uncounted "factors," acting together in various ways. Any single factor depends for its appearance and form of manifestation on all the others, as Wilson has urged. It is not a thing by itself; it is the result of a complex equation. Sometimes we are getting along well enough with our experiments, when suddenly things go wrong; not because of error in our theory, but because some new factor, which we were not watching, has come in and disturbed the results. Thus, in breeding red sunflowers, we predicted, and got, a dark red homozygous flower. We also got, but did not predict, a homozygous red in which only the basal half of each ray was of that color. The fact is that many of the wild sunflowers carry a factor for marking, which can be seen with difficulty on close inspection, but in the red it comes out strongly. For reasons of this sort we have not only the complications due to the multitude of factors or determiners, but also those caused by their interactions. Inasmuch as they may influence each other strongly or slightly, and in all sorts of different ways, the net result is that in the more complex types of life we have almost infinite possibilities of variation, quite aside from any question of the alteration of the determiners themselves. Add to this the complications due (it appears) to accidents in the maturation process of the germ cells—such an "accident" probably gave rise to the red sunflower—and we have in most cases as much material for natural selection to operate upon as Darwin or Wallace ever postulated. Enough, indeed, to account for all the wonderful adaptations in the tropical fauna and flora, when we consider the time available for their production.

It has recently been announced, as the result of the museum work of Dr. K. Jordan, combined with the field and breeding observations of Dr. G. D. H. Carpenter,[3] that an African butterfly of the genus *Pseudacræa* occurs in a variety of forms, which imitate species of *Planema* flying with it. The extraordinary thing is that one phase of this *Pseudacræa* is sexually dimorphic, imitating a dimorphic *Planema,* while in the same forests it also occurs in two monomorphic forms, resembling two other monomorphic species of *Planema.* Dr. Carpenter succeeded in breeding one of the monomorphic *Pseudacræas* from an

[3] *Entomologists' Record,* XXIV. (1912), p. 233.

egg laid by the other. In a case like this, we have the result of a Mendelian experiment performed by nature. The different phases are represented by interchangeable units, and interbreeding normally occurs. Hence, an extreme case of polymorphism, in which *all* the alternative forms which have been preserved are at present favored in the struggle for existence. Of those which, in the ages past, have disappeared, we have now no trace, but theoretically we should expect some non-mimetic recessive combinations to occur as occasional aberrations. This, I believe, accords with the facts.

Those who examine remarkably adapted forms are always impressed by their striking characters, and find it hard to believe that they have arisen by gradual steps from the more ordinary types. They do not appreciate the ages during which these forms have been evolving, and the multitudes that have perished. Among insects, however, the number of surviving species is usually much greater than in any other group of animals, so that it is possible in a certain sense to compare a specialized type with its ancestors, or at least with contemporaneous species having many of the marks of its ancestors. For this reason insects are exceptionally valuable for the study of evolution; though hardly equal to mammals, which have changed so rapidly within comparatively recent times, and have left us such admirable fossil remains. It would be a useful contribution to the theory of evolution to take up a number of the cases of mimetic or otherwise peculiar insects and show how they are connected by many steps with the more ordinary forms. This has, indeed, been done in part, but it has been difficult, requiring immense and carefully worked out collections. In the Lepidoptera, where these studies are most interesting, the work is being immensely facilitated by the publication of Dr. Seitz's magnificent volumes on the Macrolepidoptera of the world, which place descriptions and good colored figures of all the principal larger Lepidoptera at the service of any one who can afford the very moderate price charged.

We may consider, for example, the "Aristolochia Papilios." These splendid butterflies feed in the larva state on *Aristolochia,* rarely on allied plants. They occur on both sides of the world, and are doubtless, as a group, of great antiquity. They are strong-smelling and apparently distasteful to most predatory animals; the other two groups of *Papilio,* not thus protected, frequently produce species which closely imitate them, so much so that "until quite recently models and mimics have often been regarded as closely allied." The great Indo-Australian series of Aristolochia Papilios shows the largest size and extraordinary sexual dimorphism in the *Ornithoptera* series, usually treated as a distinct genus. The great diversity of the sexes, both in form and color, is extremely impressive in view of what we now know about sex-inheritance. The bright colors are most commonly orange, often green,

while the male of *P. urvilliana,* a Solomon Islands species, is marked with blue. The absence of red is noteworthy,[3] although it is not complete, several of the species having a little red on the anterior edge of the thorax or back of the head, or on the under side of the thorax. In the allied tailed series (including such forms as *P. hector* and *coon*) light red spots are frequently developed on the hind wings. The American (neotropical) Aristolochia Papilios, which are much smaller on the average than the oriental, have the markings and form for the most part much like the orange and black oriental group (*P. darsius* of Ceylon, etc.), but where there is orange on the hind wings of the *darsius* group, it is usually bright red in the neotropical series, though occasionally orange, or orange shaded with red. Most of the American species have well-defined patches on the anterior wings also, but these are green, yellow, white or rarely blue, never red. American Papilios of the *lysithous* group resemble the Aristolochia Papilios of the same region in the most amazing way, and these mimetic butterflies are said to usually imitate the sluggish flight of their models. When we have figures of all these insects and their allies before us, we can see how some of the most peculiar types are connected with quite ordinary ones by intermediates, and how each group works on a certain series of available colors and patterns to reach its results.

[3] *P. hypolitus* Cr. (male) is figured as having red on the abdomen. This is probably a mistake, as the description says dark yellow.

SOME RANDOM THOUGHTS CONCERNING COLLEGE CONDITIONS

By Professor JOHN J. STEVENSON
NEW YORK UNIVERSITY

AN ever-increasing proportion of the community seems to be convinced that every youth, male or female, on American soil, has a natural right to collegiate and even to professional education at nominal or no cost. That so many have been deprived of the opportunity to acquire a college degree is one of the saddest of the world's many tragedies; good men and women, having exhausted the joy of conscious usefulness in the ordinary philanthropic operations, find new zest in contriving methods whereby those excluded from college attendance may secure the coveted parchment with a minimum of expense and inconvenience. Their efforts to increase the roll of "American nobility" find ready support on the part of college authorities, who are always prompt to aid any good work which promises to increase the enrollment.

This popular conviction surprises no one who is familiar with the history of American colleges. In the early days of this country, when schools of any kind were few, clergymen were compelled to educate their successors or to have none. Those devoted men extolled the honor of their profession, they cultivated respect for knowledge, they awakened ambition in young men as well as in their parents; and they undertook the labor of instruction when candidates for the ministry presented themselves—many times taking them to their homes and sharing with them their scanty fare. No one imagined that any credit was due for this self-denial and added labor. The work had been, so to say, thrown in; it had cost the teacher nothing; he had parted with nothing material and the teaching had produced nothing tangible; at most, he had utilized only spare hours, which, in any event, belonged to the people who paid him a small stipend. In fact, the parents of the young men thought that the loss sustained by deprivation of their sons' services entitled them to credit equally with the pastor; and they were not far wrong, for the education was to fit the son not to gain a livelihood, not to gain higher social position, but to enter a profession which at that time meant little more than poverty and an opportunity for service. When population became denser, pastors opened academies to increase their incomes, but the shrewd people succeeded in turning this to their advantage; the writer has seen a "call" offered more than a century ago, in which the right to have an "academy" was noted as an

inducement. When these "Latin schools" grew into little colleges, parents and students alike knew that requirements of duty were fulfilled by payment of a small fee; the instructors were mostly clergymen who eked out their incomes by serving neighboring churches. It is said that of the first 110 colleges in this country, 100 were founded with training for the ministry as the prime object. The importance of education received full recognition, but teaching as such was not regarded as a serious matter; it was merely an incidental part of a minister's work. The belief prevailed that if a young man was willing to accept an education some one ought to give it to him.

Until 75 years ago, college teaching in the greater part of this country was controlled by clergymen, members of an ill-paid profession. Even now a large proportion of our college and university presidents are ministers, and there are many in prominent places who maintain that higher education should be under clerical supervision. The tradition continues that teaching like preaching is, or should be, altruistic work and the salaries are graded accordingly. Some time ago the president of a great university blamed this lack of appreciation on the materialistic tendencies of our time, casting all on that convenient beast of burden, commercialism. But this is without reason. Failure to appreciate the work of college professors is merely a survival of the hard materialism of early days, when pioneers struggled against a harsh climate and gained their farms by felling the forest. Genuine appreciation of intellectual work comes only in an age like this; it comes with advancing civilization, when men have been freed from bitter contest with nature, with the physical comfort found only in commercial communities, such as Athens, Babylon or Thebes, in the olden times, or the great commercial centers of modern times. Our business men recognize the power of pure intellect; they pay its possessors almost fabulous salaries; they endow colleges and universities in the hope that intellectual training will enable the coming generation to begin where they have left off and to accomplish greater things. The blame for wretched salaries and constantly increasing overwork can not be laid at their door. The scale was fixed originally by clergymen, the one class against which the vague charge of commercialism can not be laid. If the happy day should ever come when lay members of college boards awake to the sense of their responsibilities and gain personal knowledge of the kind and amount of work done by college professors, the complaint respecting small salaries will be at an end.

Conditions have undergone great change since the days of the "Latin schools." When population was sparse, when little money was in circulation, though the people lived in comfort, the modest college, with few teachers, small fees and narrow curriculum, was necessary if the professions were to be recruited. But those conditions have passed

away finally; commercial intercourse is complete and the small farmer handles more money than did his wealthy predecessor of a century ago. College is sought no longer only by those destined for the "three learned professions"; young men of all aims, and a multitude with no aims, are enrolled in the classes; it has become the thing to own a diploma. The faculty no longer consists of five or six men, each supposed to be familiar with everything in the curriculum but, in all reputable colleges, it is composed of teachers who have spent years in special preparation for the chairs which they occupy—a college professorship is no longer regarded as a haven of rest for men who have failed in some other walk of life; the curriculum has been broadened in all directions and the cost per student has been increased by several hundred per cent.

In spite of the changed conditions, colleges, and to a great extent professional schools, are still regarded as closely allied to charitable institutions. The presidents of starveling academies with a college annex go about the country pleading the cause of their poor self-denying professors; colleges are exempt from all ordinary taxation; they maintain costly fields for semi-professional athletic contests to which admission fees are charged; they are permitted to reserve large parks around their buildings, even though the reservation be to secure an unearned increment. This conception that colleges are charitable institutions does comparatively little injury to the community, but it does far-reaching injury to the staff of instructors in that the salaries are adjusted on the altruistic basis. It is felt that the work is so lofty in aim and so important to the human race that no consideration of pecuniary reward should be permitted to corrupt the worker. Not long ago a western association of college teachers resolved that, in their opinion, the minimum salary for a professor should be at least $1,400. The president of one of the colleges asserted that such a minimum would be absurd; that, if the rule were enforced, a very great proportion of the colleges west from the Mississippi would be driven out of existence. If that should be the result, devout lovers of true education ought to establish at once a chain of prayer meetings to bring about the enforcement of that minimum.

But it is very difficult to believe that young men or young women have an inherent right to receive higher education at another's expense. If one can earn such education, it is his right; if another choose to earn it for him, no one may criticize either giver or receiver. All recognize the parent's duty to give to his child every advantage within his means, even at the cost of great self-denial, for he brought that child into the world without its consent. But the responsibility of others ceases at an early stage in education, far below the requirements for college entrance; it extends no farther than the community's protection demands. A wise community will go beyond the limit of its absolute responsibility

and will afford opportunity to acquire enough knowledge to let the youth rise above mere muscular labor; but even this is still far below the demand, for college or professional education is in no sense essential to the attainment of wealth, of political or social distinction or even of great usefulness. There is no more of real charity in endowing a college than in endowing a great hospital, open to rich and poor alike, at nominal or no cost, on the basis of first come, first served.

For colleges are conducted on that principle, as are some dispensaries which make no investigation respecting needs of applicants, and the "charity" appeals for aid in proportion to the amount of business done. No properly equipped college can subsist on the fees as now arranged; each simply doles out alms to rich and poor alike, presenting them in many cases to men who would scorn a gift in money. Too often, a college in appealing for more endowment is asking wealthy men and women to aid it in giving the college course to the children of other wealthy men and women at a fraction of the cost. The condition is worse in the case of professional schools, in which the fees should always cover the cost; the more so, since there is no pressing need for more lawyers, physicians or even clergymen. In this, there is no criticism of those who endow professorships or free scholarships, provided always that they do so wisely. Scholarships should never be given, they should be earned in competitive examination. A professorship should be endowed so generously as to make the salary attractive to ambitious men who have been accustomed to comfortable surroundings; if the income be so small as to be attractive only to those who have served an apprenticeship in poverty, the gift is injurious. Teaching is not the only function of a college; the professors should be investigators also; the man who does not make original studies becomes a dealer in second-hand knowledge, a mere lesson hearer; whatever his salary may be, it is enough. Up to thirty years ago, a stream of contributions to knowledge flowed from the colleges; a great part of the country's advance, intellectual as well as physical, is directly traceable to that stream. But, during later years, the importance of increased enrollment and the necessity for accommodating the increasing number of students without increasing the expenditure or the fees have overshadowed all else; the efficiency system of the factory is applied, the hours of teaching have increased in many cases to beyond those required in the public schools; so that college men of the present generation have neither time nor energy to do such work as was done by their predecessors. Any unrestricted endowment gift which may be utilized to provide an additional number of low-priced instructors so as to accommodate an increased number of students at cheap rates is destructive.

And here one touches the real disease affecting American colleges. There has been a gradual lowering of the actual, not professed, stand-

ing during the last twenty-five years. Constantly increasing enrollment is, for most college presidents and most college trustees, the only proof of success. Canvassing for pupils is as much part of the college plan in some portions of the country as drumming for customers is in a wholesale business house. Of course, no such vulgar conduct is countenanced by the older institutions, which never send their presidents or special agents on such errands. They utilize students as wandering minstrels, who appear as the blank college or university glee club; they have trained bands of student gladiators to contend in intercollegiate contests and they do not discourage the custom of impressing a great part of the student body as "rooters" for the team. Even the great universities do not think it undignified to advertise the attractions which they offer in college or professional schools. In small colleges, the president often announces his annual or semi-annual canvassing tour as systematically and unblushingly as did the commission salesman of 40 years ago. In larger colleges, the annual tour of the president, during which he makes the round of alumni clubs, is a fixed part of the program. He is not scouring for students, but in his addresses he dwells lovingly on athletic successes, on the pecuniary gains during the year, on the remarkably democratic life of the students; he extols the great advantages offered by his college and urges the alumni to prove their loyalty by spreading the facts broadcast and by giving some money to make matters "more so."

The ingenuity of the canvasser and the exigencies of his concern lead some perilously near to something more than mere inaccuracy of statement. The latest achievement is calculation of the proportion of college men recorded, in "Who's Who." The statistics are correct, but the deductions are imperfect. No note is made of the fact that the plan of the American "Who's Who" leads the editor to select chiefly men whose occupation presupposes college or university work. A search for truth would have led not to "Who's Who" but to biographical catalogues of college alumni. That study might have led to discovery of conditions on which the canvasser would have been more than unwilling to enlarge. Certainly, he would have come to wonder why it is that "Who's Who" is so small a volume, as there are so many thousands in this country who own college diplomas.

The presentation is uncandid, for it is intended to convince young men and women that some magic force insuring success resides in the college course—which is not the fact. The college professor is no alchemist to change dross into fine metal; a gymnasium can not give legs to the man born without them; no more can the college professor give mental power to the one who has it not. Men are born as unequal mentally as physically and not all can gain material advantage from college work, though there are few who can not obtain a diploma somewhere.

The elements of success are innate, their combination is complex; without them a man can not succeed, with or without a college course. A college professor accustomed to study his students can make reasonable forecast of their future by end of the sophomore year, if he know their home surroundings. Mere success in college studies means nothing of itself for the future; one valedictorian disappears at once after graduation while another quickly becomes a power for good or for evil. A fellow with low grades throughout startles professors, whose work he detested, by becoming a great man.

Not every young man should be urged to go to college; entrance may be the first step on the road to hopeless failure. The fact that a man is willing to go to college, even the fact that he is willing to endure hardship to secure an "education," is no reason of itself why he should have the opportunity at another's expense. He may be very earnest, but he may lack capacity, or he may have grown up amid surroundings which have dwarfed or stiffened him so that he can not receive much benefit. Such men or women should not waste their time in college. The writer makes this assertion feelingly, for a long procession of such failures passes before him, as he reviews his forty years of college teaching. Earnestness is no evidence of capacity; willingness to endure very serious inconvenience may be evidence only of willingness to follow lines of least resistance. Four years of self-denial at college may be far preferable to four years of hard work on the farm or in the shop. One may remark, parenthetically, that a vast amount of sympathy is wasted on men who work their way through college as though they were a superior type of the race. No man deserves any special credit for undergoing hardships in order to secure what he believes will yield great returns. The gold-hunters of the Klondyke did that and asked neither praise nor sympathy. The men who struggled to make their way through college and who proved in after life that they made that struggle with clear purpose for the future, ask no consideration and challenge the world to accept them for what they are worth. But our land is full of lawyers working as petty clerks, of physicians without practise, of clergymen whom no one wishes. They are embittered against the unappreciative world, which ignores the struggles they made to secure an "education" and insists on taking them at its own valuation. Had it not been for cheap tuition, college canvassers and boards of aid, a very large proportion of these men would not have gone to college and might have led a comfortable existence in some occupation for which they were fitted.

In all frankness, one must concede that the college of to-day does not fit a man for anything—it does not even train him to do clear thinking for himself. In early days, the curriculum was utilitarian in the severest sense of the term. Latin and Greek were learned as languages

because they were to be used. Those languages were, so to say, the vernacular in divinity schools. The writer's grandfather was accustomed to assign a lesson of twenty or thirty pages for discussion on the next day, and the students were expected to discuss the theology, not the Latin construction. One can not repeat too often or too emphatically that Latin and Greek were the all-important elements of the curriculum because they were to be utilized, just as arithmetic has its place in primary instruction. The incessant chatter, which one hears now, about the intellectual strength gained by study of the classics would have excited derision on all sides in those days. When Latin and Greek lost their utility, American colleges should have seized the opportunity to remodel the curriculum throughout; but the opportunity was neglected and the curriculum became a series of compromises between the old and the new, developing at length into aimless election or narrowing groups, the one encouraging shiftlessness, the other tending to weaken the reasoning power. College officials were roused to indignation several years ago by criticisms offered by two prominent business men; the outbursts in some instances were so violent that one might suppose that these philistines had invaded a holy of holies. But one must be judicial. Much of what those critics said is inaccurate, having been accepted on information and belief; but that which they stated as of their own knowledge was true and is true—and too many of the statements were made as of their own knowledge. Every college professor, whose observations extend beyond the walls of his classroom, knows that the criticisms contain only too much that is true. The aimlessness of broad election and the narrowness of groups are destructive.

The able president of one of the best American colleges is reported to have said:

> A college is an institution where young men and young women study great subjects under broad teachers in a liberty which is not license, and a leisure which is not idleness—with unselfish participation in a common life, and an intense devotion to minor groups within the larger body, and special interests inside the general aim; conscious that they are watched by friendly eyes, too kind to take unfair advantage of their weakness, yet too keen to be deceived.

The concluding phrase, "yet too keen to be deceived," must have been penned by one who has forgotten his student days. It will be read with delight by college graduates and will give new sense of security to undergraduates. This example of admirable English and inspired imagination has been of much service to canvassers for so-called colleges and has received more than favorable comment in several addresses. It has been the theme of many a commencement oration and has given zest to many a baccalaureate sermon. But, as presented by its author, it is defective. If he had said the "ideal college," no exception could be taken to the statement; it would be absolutely correct. But

the reader, acquainted with actual conditions, finds himself commenting involuntarily on some of the expressions. If one read records on sporting pages of the great dailies, he will soon discover that the great subjects are athletics and that the broad teachers are professional coaches, who receive larger remuneration than that of the professors. If he read addresses of college presidents at alumni gatherings and consult the columns of college papers he will find little reason for change of opinion. Nor is he likely to find anything different if he look in other directions, though he may gain enlightenment respecting the minor groups or special interests.

A leading metropolitan daily published once a week two pages of news calculated to bind alumni to their colleges—all reference to athletics being avoided. The communications, many of which carried earmarks of official sanction, were examined during several months. Barely 9 per cent. of the space dealt with the curriculum, increased facilities for study, with the work of professors; aside from the incidental references to such matters, the space was devoted to information respecting glee clubs, society politics, college theatricals, glorification of the democratic spirit among the students, the peculiar advantage of the college over its rivals, with not infrequently a more than casual reference to athletics. In comparatively few instances is anything recorded which would lead a wholly uninformed reader to suspect that college is a place for study—and most of those references are not from colleges but from technical schools. If one consider the important place which these interests occupy in the mind of so-called students, and if he add to them football, baseball, lacrosse, hockey, wrestling, boating, swimming, gymnastics, as well as daily, weekly or monthly publications, he will feel convinced that for a great part of the students none too much time remains to be expended or, as some college boys would say, wasted on study. He will be confirmed in his conviction when he observes that intercollegiate contests are not interrupted by such matters as reviews or approaching examinations. The college course need be little more than leaning against college walls for four years—a simple luxury. The opportunity to acquire knowledge and intellectual training is offered, but students are not compelled to accept it or to leave. A man must be a dullard or an idler indeed who can not gain the passing mark by incidental study and by reasonable attention during recitation hours. Frankly, there is no sense in showing surprise or irritation when business men, demanding 98 per cent. efficiency for promotion, designate college work as a four years course in the science of shirking. The absurdity of the conditions appeals to the professional jester, the "student" has displaced the mother-in-law and the politician.

Some prominent universities have informed the community that the college course is not so important as some good people imagine. A de-

cade or more ago several institutions decided that the fourth year in college is unnecessary and agreed to accept in its place, as counting for the degree, the first year in medicine, law or theology; and now comes the startling announcement that work of similar kind is to be accepted in some cases for the third year also. Fifty years ago, the medical course required two years; now it requires four; but the bachelor degree and that in medicine can still be secured in six years as they could fifty years ago. The writer offers no objection to this, as medical study requires work, but such open confession of the degeneracy of college work was hardly to be expected.

Business men are censured for lack of appreciation because they hesitate to employ college-bred boys,[1] but this is unjust. The college graduate has heard so much about the advantages of an "education" that he expects to find a scramble for his services as soon as he waves a diploma. Without loss of time, he discovers that, in so far as business affairs are concerned, his sojourn within college walls has given him little, it has fitted him for nothing and that it has unfitted him for much. Not long ago, some of the New York dailies had columns of letters complaining bitterly of the miserable pay given to college graduates in business offices. Certainly the pay was small, so very small as to suggest that the complainants would have been employed better in self-examination than in writing letters. There is no reason why a business man should pay more to one incompetent clerk than he does to another. Graduate or non-graduate, that is a matter of indifference; the most efficient man receives most; the graduate must begin where others begin—at the bottom—for, at the outset, all are alike ignorant of business affairs. One must concede that college life does not tend to make business men. The college code of honor would not be tolerated for an hour in a business office; from time immemorial, cheating in examinations has been regarded as justifiable to avoid failure, though cheating to gain honors has always been looked upon as base. In the former case, only the faculty is swindled, but in the latter, injustice would be done to a fellow-student. In a business office a man must do his work thoroughly, no 60 per cent. is a passing mark there. Even the class room atmosphere is not always good. Too many college professors know little of the world outside of their community and the utterances of their favorite newspaper or magazine. They have acquired, subjectively, many and serious convictions respecting the moral condition of the community, chief among these being the inherent corruption of commercial life. The student absorbs the doctrines and goes forth burdened with the responsibility of eliminating the crimes, which he is soon to discover are no more prevalent in business than in professional life, being merely the outgrowth of poor human nature.

[1] This does not refer to graduates of schools of applied science.

The constant endeavor after "broader fields of usefulness" does great all-around injury. The anxiety for a constantly increasing number of students, instead of for high quality of work, compels frequent and wasteful public appearance of presidents and professors, that the college may become known to those who do not read the sporting pages of great dailies. The importance of a college education is a staple for editorials in religious journals. Inventive genius is strained in the effort to discover new methods of doing good. One university boasts of 5,000 correspondence students and another of 4,200; others have reached the status of boasting, but without giving details. It has been announced that, by correspondence, one may easily complete the first two years of the college course. Some prominent universities have admitted that the last two years of the course are unimportant; others are endeavoring to convince the community that college attendance during the first two years is quite unnecessary. If the chief purpose of college attendance be to gain a diploma, one must acknowledge that they are all quite right. Students enrolled in correspondence have not reached the dignity of a place in the catalogue, but they need not feel discouragement; correspondence schools, like the summer schools, can not be ignored, and soon the enrollment in some American universities will rival that of medieval Italian universities.

The example of larger universities has not been lost upon small colleges, for they, too, recognize the great importance of extramural work. The writer has just received the bulletin of a small co-educational college, which includes in its scope a college, an academy, a school of pedagogy, a school of music and a school of art. The college curriculum is divided into the proper number of groups, so that the student may specialize promptly with a view to future work. The professors offer from 15 to 31 hours a week in the first semester of the college, which might be regarded by some as a reasonable requirement in the way of work, especially as it appears to be supplemented by duties in the academy. But this is clearly a mistaken opinion. The institution is "planning to bring college instruction, with college credit, to many who can not enter the college halls." Saturday classes, evening classes, correspondence work are offered. Affiliated instruction is proposed for communities which members of the faculty can not reach; high-school instructors, ministers and others of the locality will be in charge of the classes and college credit will be given. Popular lectures by members of the faculty on lyceum and platform occasions, Memorial day, Sunday-school associations, etc., are available; and the college offers lyceum courses of five entertainments for $100 a course, including two concerts, an entertainment in the way of recitation and singing, and two lectures of popular or semi-popular character. "Write

us your needs." Finally, it is announced in bold type that full college credits will be given and that the fees will be moderate. One must not fail to note that the athletic teams of this college rank high; there are less than seventy male students, of whom 60 per cent. are freshmen and partials. Truly the scope of college work is expanding; dressmaking and folk dancing have attained the rank of university studies and, judging from past occurrences, there is every reason to suppose that they too will find their place along with other studies in literature and pure science among qualifications for the Ph.D. As that degree has now an actual commercial value to the possessor, the college should make its requirements not too severe.

But one can not contemplate this amazing increase in the number of candidates for degrees without apprehension. It was not without reason that a foreign visitor recently spoke of the American as "education-mad." A note of alarm was sounded in France several years ago, because there were 36,000 students in the universities and professional schools; it was thought ominous for the republic's welfare that so great a number of Frenchmen were looking forward to professional life, to abstinence from physical labor: how much greater is the danger here, where colleges claim an attendance nearly ten times as great; the greater proportion of the students are looking forward to teaching or some profession. Kinds of degrees are multiplied to suit the capacity or lack of capacity of the hoped-for students; hundreds of Ph.D.'s are put forth each year with narrow specialized training, most of whom expect to be employed in colleges where they may promulgate their *a priori* doctrines respecting conditions and remedies. Manual labor is despised; the youth of the land are flocking to the cities, which are already overburdened with the class not "fitted for anything in particular"; the trades are passing into control of aliens who exploit the country. They give opportunity to radicals for denunciation of a cold-hearted community which permits them to wallow in wretchedness and in a few years they return to their own land with a competence.

The wide-open door to higher education is not just to the community. Many writers appear to hold that the salvation of this country depends on education of all the people and college canvassers find in this a noble text. But secular education is no panacea for evils, public or private; on the contrary, it may aggravate them. Intellectual training in no wise affects the moral sense. Even in denominational colleges of the strictest type, direct moral instruction must be subordinate and somewhat generalized; and in any event the value of such instruction depends wholly on the standing of the man who gives it. The average professor in our larger colleges is hardly so important as the football or rowing coach, while in small colleges such instruction

is given too often by one whose profession is along that line and the student is apt to think that it is only business, any way. But at best, instruction in morals comes to only too little, as one may see in professional schools. In those, the whole training from the very beginning tends to enforce the doctrine that a keen sense of honor is essential in professional life, yet one finds that in all professions—without any exception whatever—there is too great evidence that training in this respect has done little to overcome the natural tendency of mankind. Unless the surroundings, whence the student has come or amid which he lives, are such as to strengthen the moral tone, the man is likely to gain little in college, while the many special and unavoidable temptations of college life increase the danger of losing much that he already had.

There is need of notable changes in college affairs.

The waste of time in preparation for entrance is prodigal. The requirements for admission to the classical course in New York state when the writer entered college in 1858 were practically the same as now in Latin and Greek; there have been added almost a year of mathematics and, nominally, three years in English. The word nominally is used advisedly. The modern requirements are arranged with great show of importance and consist of study of some examples of fine writing; but they are a wretched substitute for the severe drill in the use of English, which was an important work in all private schools. The average city boy in the 50's, beginning systematic study when eight years old, usually completed preparation for college when he was fifteen and very many times when fourteen; it was believed at that time that the preparatory schools had attained the limit in the way of lengthening the period, and it was recognized that an ordinary boy could complete preparation by the time he was thirteen, without any strain on his health or interference with recreation. The now prevailing anxiety for the health of pupils, the craze for "short lessons well prepared" and the desire for continuing receipt of tuition fees have added unnecessarily three years for preparation. The padding of high and grammar school courses with unessentials to the utter neglect of such essentials as reading, spelling and the proper use of the English language may be justified by the necessity for holding pupils as long as possible to provide opportunity for more teachers of the higher grades, but it is not justified by the product. Boys are not so well trained at eighteen as they were fifty years ago at fourteen. They do not think, they do not know how to think; the modern method seems intended to prevent all necessity for mental exertion and the text-books are as easy as padded crutches. The mental drill which should be given to the youthful pupil has to be given in the freshman class at college. The college authorities should demand less in mass but more

of thoroughness from the preparatory schools; entrance examinations should be to determine how well the boy has been trained, not to ascertain how fully he has been crammed. It may be well enough for colleges to waste their students' time in athletic contests for advertising purposes, but such "commercialism" in preparatory schools should be treated with indignation.

College methods should be changed. But first of all, there should be a definite legal determination as to the meaning of the term "college." The several states should respect themselves and should repeal the charters of many schools which have power to grant degrees. Drastic treatment has been applied to medical schools within the last two years and similar treatment should be applied to academies which masquerade as colleges and count as students all pupils, even those in the primary department. It has been said that the existence of such colleges is justified in many places, for the question is either poor colleges or none. Not at all. There is no reason why these academies should be called colleges and be empowered to grant degrees which the recipients think equal to those obtained from colleges properly equipped with men and materials; they should be recognized only as academies and as such they should be self-supporting. There is so reason why an academy in a prosperous community and with 400 pupils should not be self-supporting. If comfortable farmers are unwilling to pay the cost, that is no reason why overtaxed city dwellers should meet the deficit; the canny agriculturist has overreached the great cities sufficiently through methods of real-estate assessment.

The cost of some so-called "colleges" is appalling. The writer recently received a circular appealing for assistance to save a college whose prosperity threatens its existence. The "institution," in a prosperous agricultural region, has almost 500 pupils, including the summer school, whose utility in swelling the catalogue list has been discovered. Of the grand total only one seventh can be classed as taking college courses and the academy contains scarcely so many. During the year 1911–12 the expenditures were almost $49,000 and the deficit was about $23,000, or an average expenditure of $100 per pupil—while the receipts from tuition fees of all sorts amounted to only about $7,500. Of the money expended, $17,000 was paid to teachers, but the other expenditures show some surprising features, for one finds $4,800 for "other salaries"; $1,000, "other expenses"; $5,600, "printing and advertising"; $1,360 for "travel," making a total of nearly $13,000 for administration and publicity in a prosperous community, which cared so little for the advantages that only $7,500 were paid as fees for almost 500 pupils. During an existence of twenty-nine years this "college" has succeeded in accumulating an alumni roll

of 63. The writer has gathered numerous catalogues and appeals during the last two years and he can present other illustrations of the same type. Whether or not a state should permit multiplication of such colleges may not seem to many to be an open question.

The real colleges and universities should come to an honest recognition of the fact that they were founded to produce mental, not physical athletes; college authorities and they alone are responsible for the common belief that, in college, intellectual work is less important than physical. "Methods of the shop" are denounced by many college presidents and by many professors as degrading; but nowhere are those methods more conspicuous than in colleges themselves. The only evidence of success, apparently, is increased enrollment, more funds, more houses, more low-priced teachers. Quantity, not quality. College presidents and professional canvassers hawk their wares as blatantly as criers at a fair; advertisements are placed in journals and circulars are sent broadcast, extolling the advantages of the institution as shrewdly as though the wares were oriental rugs; students entrusted to college authorities for mental training are utilized for advertising purposes and the college controls the process. Many colleges have a special exhibition day, when prospective students are invited to inspect the concern. Students, once gained, have an inordinate sense of their importance and resent regulation by the faculty as interference with their rights. Strikes among college boys are becoming only too familiar and the plague has found its way into high, even into grammar schools. Discipline is weakened and young Americans at college are growing up in a school of disobedience and evasion.

College trustees must change their methods; they must acquire a new conception of duty and must remember that they are custodians of a great trust for whose honest management they are responsible. The fact that under present conditions there is none to call them to account should make their sense of personal honor more acute. A trustee should endeavor to familiarize himself with the kind and extent of work done by professors, and should not consent to accept only such information as the president may think proper to present. It is little short of scandalous that great universities with thousands of students and vast properties should be controlled by men who are utterly ignorant of the work which is done or which ought to be done. There is no hope for American colleges, unless their affairs can be placed in charge of sympathetic trustees, who will recognize their personal limitations and will concede gladly that not they, but the faculties are the university. Great railroad companies have been wrecked because financiers on the board of directors insisted on managing the road according to their notions through a financier president; other great companies have been rescued from destruction by repentant boards, who confined

themselves to their proper duties and left management of the railroad to those who understand the business.

There must be a return to the proper conception of a college, a place for study, where men and women may be so trained as to be fit to undertake great things. A college should be exactly such a place as described by President Hyde in the address already cited. But that ideal college will remain ideal until the community has been led to recognize that for a third of a century the whole method has been wrong; that the glory of a university does not consist in the beauty of its buildings, the broad expanse of its campus, the extent of its athletic fields or in the marvelous equipment of its gymnasia, but in the character of its professors and in its equipment for legitimate work; that the greatness of a university does not consist in the number of its students, in the number and variety of its schools, but in the quality of the work done and in the character of the schools. The ideal condition will be impossible until those controlling the affairs of colleges have learned that they are not owners, but trustees, and have to come to recognize their responsibility as honest and honorable men; until they have become convinced that it is less important for a president to be making addresses on public affairs than it is for him to attend to college affairs —for which he should be held to strict accountability.

There must be changes in many directions. The mad chase for students should cease, requirements for entrance should be made more severe and students should be accepted, not entreated. Men unfitted by native defect or by environment should be discouraged: the fees should be increased so as to defray the cost; there should be many scholarships, but they should be granted not as gifts but only upon severe examination; they should be earned—the examination should be conducted by a central board of examiners. Intercollegiate contests of all sorts should be abolished; the great stadia should be abandoned or converted to some useful purpose; courses in gymnasia should be compulsory for all students; athletic fields should be opened for use of all and exercise should be encouraged. But every student should know that the aim in all athletic work is to fit him to do better work in the classroom—not, as now, that incidental work in the classroom is required to qualify him for membership on a team. Then, the heroes of a college will not be those who have won their "letters" by muscular prowess, but those who have made high rank in study. It will no longer be a disgrace in "halls of learning" to be a "dig," and one will not be stung by frequent repetition of the assertion that the output of colleges is not equal to that of former days.

HENRI POINCARÉ, the great French mathematician, physicist and philosopher. An appreciation of M. Poincaré was given in the last issue of THE POPULAR SCIENCE MONTHLY. Many of his articles on the foundations of science have been published in recent volumes of this journal.

THE PROGRESS OF SCIENCE

RESEARCH INSTITUTIONS

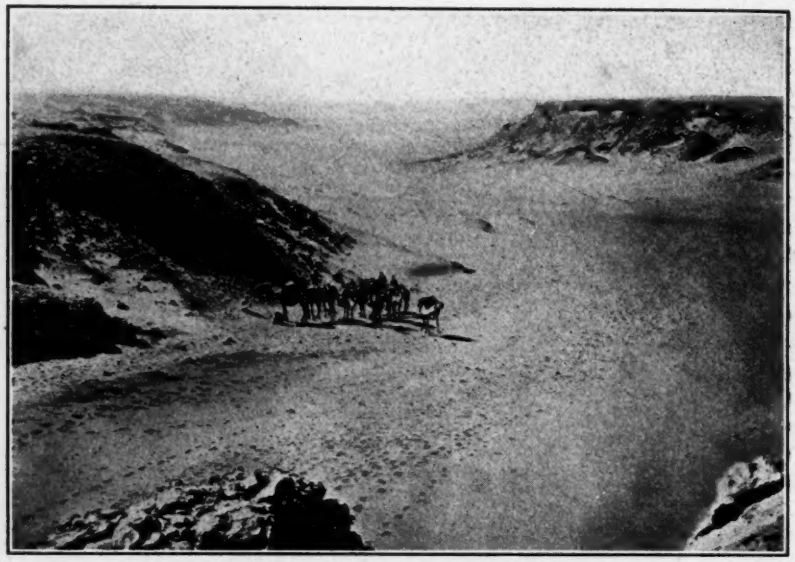
RESEARCH institutions are themselves scientific experiments on a large scale, for it is an open question whether research work can be supported to greatest advantage under our universities, by separately endowed institutions or directly by the government. While the answer to this question is important, we can safely assume that scientific and scholarly investigations should be carried forward by all possible agencies, for the returns on the average and in most cases are many fold the cost, both in economic applications and in their contribution to ideal ends. It seems undesirable to urge, as Dean Burgess of Columbia University has done recently, that the establishment of research institutions is unwise and unfair to the universities, or, as is frequently asserted, that the scientific work under the government and in the experiment stations should be confined to the applications of science.

President Woodward, of the Carnegie Institution, is certainly correct when he writes in his last annual report: "The common notion that research demands only a portion of one's leisure from more absorbing duties tends to turn the course of evolution backwards and to land us in the amateurism and the dilettanteism wherein science finds its beginnings." We can not depend, as in the past England has in large measure, on amateurs of independent means to carry on scientific research. Work such as Charles Darwin did at Down and Lord Rayleigh still does at Sterling Place is not attempted in this country. Among our thousand leading scientific men only eleven may be classed as amateurs, and they are not those of the highest distinction. Practically all our scientific men are employed by the universities, in the government service, or by the newly established research institutions.

In the universities the professors are too much occupied with elementary teaching and enmeshed in the machinery of administration. In the government service the experts are too much limited to the application of science and subject to official routine and red-tape. In both cases the salaries paid are smaller than in business concerns, and probably less initiative and freedom are allowed. The scientific man has a more desirable intellectual life; it is truly unfortunate that this should be counterbalanced by irksome restriction.

The research institutions have a great opportunity, and the two to which Mr. Rockefeller and Mr. Carnegie have given their money and their names represent a new era in the development of science. Both the Carnegie Institution of Washington and the Rockefeller Institute for Medical Research have begun well. They can draw their members from university chairs and government bureaus, whereas the reverse movement has not appeared. But it is easier to begin well than to continue in good works. The Johns Hopkins University and the University of Chicago began with new ideals of research and of the professorship, but they have relapsed to nearly the common level. The United States Geological Survey began with a fine spirit, but it can not be said that the value of its work has increased with the multiplication of its appropriation.

If the research institutions are to do for this country in the twentieth century what the universities accomplished for Germany in the nineteenth century, they must not become bureaucratic machines but must be controlled by their scientific men. They must also be fertile in teaching, no less than in research, as they



BOTANICAL PARTY RESTING IN ASCENT FROM BAHARIA BASIN, LIBYAN DESERT.

may well be through the proper use of the 'prentice system. Thirdly, they must keep in touch with the people, so that the work they do will be of benefit to the nation and will be understood to be so.

At the beginning the Rockefeller Institute appears to be fulfilling these conditions better than the Carnegie Institution, perhaps because its problems are somewhat simpler, being confined to a single group of sciences in a definite place, and cultivating a field which is generally recognized as important before all others. It is, however, the case that the Rockefeller Institute has the better organization, being under the control of a board of scientific men and

MAGNETIC PARTY *en route* IN THE ANDES, PERU.

giving its members adequate salaries and great freedom and opportunity to prosecute their work.

The Carnegie Institution undertakes to conduct work not only all over this country, but, as is indicated by the illustration, here reproduced from the annual volume, all over the world. With good men at the start, this works well, but one may have misgivings as to the ultimate outcome of widely scattered research work and scientific men directed by a president from an administration building in Washington. The Carnegie Institution would probably have done better either to have established a research university at Washington or else to have used its revenue to endow independent research institutions for special lines of work in different places.

The most desirable institutions for scientific work would probably be comparatively small laboratories conducted by the scientific men who work in them, subject only to some democratic control in case of need. Such laboratories, with small groups of investigators, having similar interests and attracting to them assistants and advanced students, would develop the spirit of cooperation and devotion which is likely to wither under the touch of superior officials and administrative machinery. It would be well if such institutions were endowed by the rich, still better if they were supported by a state or a community.

THE KALLIKAK FAMILY.

In the training-school for feeble-minded children at Vineland, N. J., is a girl whose ancestry has been traced by Dr. H. H. Goddard and is now published in a small book under the title "The Kallikak Family." The results are of general interest, both as a contribution to our knowledge of the workings of heredity and as a proof of the need of practical measures for eliminating feeble-mindedness and lessening vice and criminality in the community. The feeble-minded girl, Deborah, is a typical moron who may be self-supporting

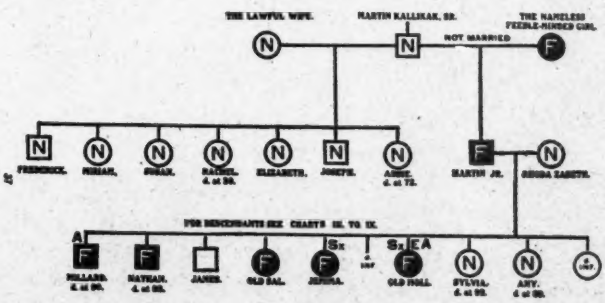


Chart I. The Two Lines of Descent Founded by Martin Kallikak.

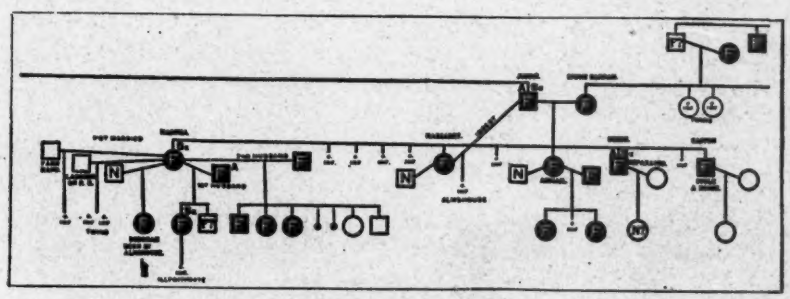


Chart II. The Family of Deborah's Maternal Grandparents.

and tolerably useful under restraint, but who would otherwise doubtless continue the family traits of her ancestry.

These are shown on the charts here reproduced. The symbols may seem at first sight to be somewhat complicated, but it is worth while to become acquainted with this kind of terminology. Males are indicated by squares; females by circles. Black squares and circles with a white "F" mean feeble-minded persons; N means normal. When there is no letter the condition is not known. We see on chart II. that Deborah is the illegitimate daughter of a feeble-minded mother, whose father and mother were both feeble-minded and whose sister and two brothers surviving infancy were also feeble-minded. This is in accordance with Mendelian expectation. Deborah had an even chance of being normal; her mother had probably none. In this whole family 41 matings have occurred in which both parents were feeble-minded; they had 222 feeble-minded children with only two who were considered normal. Justin, the feeble-minded and criminal grandfather of Deborah, was one of fifteen children of feeble-minded parents, all but one of whom are said to have been feeble-minded. The father, Millard, was the oldest son shown on chart I., the family consisting of five children known to be feeble-minded and two normal children. The parents of this family consisted of a feeble-minded father and a normal mother. The father was the illegitimate son of a feeble-minded mother and of a man of good New Jersey family to whom the name Martin Kallikak is assigned.

This Martin Kallikak afterwards married and had the additional children shown on chart I. They have had some 500 descendants, all normal, all but three good representative citizens, many of them leaders in the professions and in their communities. The almost equal number of descendants through the illegitimate and feeble-minded son supplied 143 persons known to be feeble-minded and only 46 found to be normal. Among them were 36 illegitimate children, 33 sexually immoral and 24 confirmed drunkards.

A comparison of the two lines of descent from Martin Kallikak certainly exhibits a dramatic contrast, but it is scarcely the natural experiment in true heredity which Dr. Goddard claims it to be. If, on the one hand, Martin Kallikak had left neglected illegitimate children, without taint of feeble-mindedness, it is not likely that they would have established prosperous lines of descent. On the contrary, they would probably have intermarried with the degenerate and feeble-minded. If, on the other hand, the feeble-minded son had been legitimate, he would have been properly cared for, and in all probability would have left no such descendants as came from the illegitimate and neglected child.

SCIENTIFIC ITEMS

WE record with regret the death of Dr. John Shaw Billings, director of the New York Public Library, previously surgeon and lieutenant colonel in the army; of Dr. Philip Hanson Hiss, professor of bacteriology in Columbia University; of Mr. John Fritz, the ironmaster of Bethlehem, Pa.; of Dr. Samuel Allen Lattimore, emeritus professor of chemistry at the University of Rochester; of Sir William White, F.R.S., the distinguished British naval architect, and of Dr. G. de Laval, the well-known Swedish engineer and inventor.